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ENGINEERING:

An Illustrated Weekly Journal.

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See Illustrated Advertisement Page 109, Jan. 28.

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HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

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See Advertisement page 102. 9091

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All communications to— H. W. REID, General Secretary. Head Office— 95, Belgrave Road, Victoria, London, S.W.1.

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See Full Page Advt., page 67, July 22.

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Forgings, Castings, Bars, Sheets, Wire, Tubes.
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See Full Page Advertisement page 71, July 22.

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Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 9030
See half-page Advertisement, page 73, July 8.

The Manchester Steam Users' Association.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, Mount Street, Manchester.

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The course of study covers three years, and leads to the Degree of B.Sc. in Metallurgy. There are separate courses for Metallurgists and Metallurgical Chemists.

Special attention is devoted to Iron and Steel; Copper, Brass and Local Industries; and to preparation for Colonial and Foreign posts.

Research and other Scholarships.

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Secretary.

Finsbury Technical College.

(Leonard Street, City Road, E.C. 2.)

Dean for the Session 1921-22, Professor W. H. Boodle, D.Sc., F.R.S.

The College provides for the Scientific Training of Students who desire to become Civil, Mechanical or Electrical Engineers, or Chemists.

A certificate of proficiency is awarded by the Institute to students who satisfactorily complete a Two Years Course of instruction; and the Diploma of the College is awarded to students who attend a Three Years Course and who pass the prescribed Examinations with distinction.

Candidates are required to pass an Entrance Examination in Mathematics and English, but the Matriculation Certificate of any British University and certain other qualifications are accepted by the Institute in lieu of the Entrance Examination. The Entrance Examination for the Session 1921-22 will be held on Tuesday, September 20th next. Applications for admission should be forwarded to the College not later than the 15th September, on forms to be obtained from the Registrar, Leonard Street, City Road, E.C.

The Programme of the College is under revision and will be issued in due course. R 576

THE INSTITUTION OF CIVIL ENGINEERS.

The Council Invite Associate

MEMBERS who are under 30 years of age and Students of the Institution to SUBMIT DESIGNS in competition for a Charles Hawksley Prize, 1921, which is offered for proficiency in the design of an engineering structure combining artistic merit with excellence of constructional design.

Particulars of the competition may be obtained from the SECRETARY, The Institution of Civil Engineers, Great George Street, Westminster, S.W. 1. R 564

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Inst. C.E., I. Mech. E., B.Sc.,

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THE METROPOLITAN ASYLUMS BOARD invite

Tenders for the opening up,

repairing and closing up the engines, &c., of the RIVER AMBULANCE STEAMER "GENEVA CROSS," in accordance with specification prepared by Mr. Thomas Cooper, M.I.C.E., Engineer-in-Chief to the Board.

Specification, conditions of contract and form of tender, may be obtained at the Office of the Board, Embankment, E.C. 4.

Tenders addressed as noted on the form must be delivered at the Office of the Board not later than 10 a.m. on Wednesday, 10th August, 1921.

DUNCOMBE MANN, R 608
27 July, 1921. Clerk to the Board.

TO FIRMS WANTING CONTRACTS.

Tenders are Invited from

Large and Small firms for the Manufacture in various quantities, on a repetition basis, of the following, either separately or collectively:

(1) BRASS DOUBLE-ACTING HAND-OPERATED AIR PUMPS, 4 in. bore by 12 in. stroke;

(2) COMBINED DIRECTION CHANGING CONTROL COCK AND SAFETY SWITCH for above (no electrical knowledge required), and

(3) DOUBLE DURALUMIN TANKS in several sizes and with the air exhausted from one chamber.

It may be desirable to allot work to one or to several firms, according to circumstances. Allotment of contracts depends entirely upon terms and the advertiser does not bind himself to accept the lowest or any tender. Complete working drawings, specifications and manufacturing details will be forwarded upon application and payment of the fee of £1 1s., which fee cannot, under any circumstances, be returned.

Applications should be addressed to Mr. H. GEORGE HARLEY, Consulting Engineer, at Grand Avenue, Camberley. R 573

EDINBURGH CORPORATION ELECTRICITY SUPPLY.

PORTOBELLO STATION.

The Lord Provost, Magistrates and Council invite

Tenders for the Following

WORKS:—

Specification No. 37.—Contract relating to Open Cuttings and Tunnel between the Power Station Site and Coal Sidings Site, including the construction of a Coal Bunker and Access Shaft, and the earthworks for Coal Sidings and the Laying of Permanent way and Ballasting for same.

A copy of the Specification, Conditions of Contract, and Drawings, can be obtained from the ENGINEER, Dewar Place, Edinburgh, on or after August 1st, 1921, upon payment of a deposit of three guineas. An additional copy of the Specification and Drawings can be obtained on payment of a deposit of two guineas. These deposits will be returned after the receipt of a bona fide tender and on return of the Specifications and Drawings.

Tenders on the prescribed form enclosed in sealed envelopes addressed on the outside "Electricity Supply."

Tender to Specification No. 37 must be delivered at the Office of the undersigned not later than the 29th August, 1921, at Ten a.m.

The Council do not bind themselves to accept the lowest or any tender.

A. GRIERSON, S.S.C.
Town Clerk.

City Chambers,
Edinburgh, 26th July, 1921. R 584

Re TAYLOR, SON & ROBERTS, LIMITED
(In Voluntary Liquidation),
"BRIDGE WORKS," WHEELWRIGHT ROAD,
BROMFORD, BIRMINGHAM.

TO ENGINEERS, MANUFACTURERS AND OTHERS.

The Receiver and Liquidator invites

Tenders for the Recently-

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MANUFACTURING PREMISES,
together with the
FIXED AND LOOSE MACHINERY,
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The PREMISES are well built, comprising large Machine Shop, 80 ft. by 80 ft., having north lighted roof in four bays, Offices, convenient lavatory accommodation, and ample Land for extension, with about 200 yards road frontage, and Long Canal Frontage. The PLANT AND MACHINERY is nearly new and by best makers, comprising Five Milling Machines, Shaping Machine, Ten Capstan, Screw-cutting, and Plain Lathes; Drilling Machines, Grinders, Crossley 20 HP. Gas Engine, Electric Dynamo, Hardening Furnace, Shafting, Pulleys, Belting, Weighing Machines, Machine and Bench Tools, &c.

The STOCK-IN-TRADE comprises Heavy and Light Finished Parallel and Machine Vices and a quantity in various stages of construction, Universal Faceplates, new Drills, Reamers, Cutters, Carriers, Machine Benders, Steel Bars, &c.

TRUBSHAW & TAYLOR are instructed by the Receiver and Liquidator to Receive Tenders for the above.

Tenders must be received not later than Wednesday, August 10, 1921, at the Offices of TRUBSHAW AND TAYLOR, 1, Newhall Street, Birmingham, marked "Tender," Taylor, Son, & Roberts, Limited.

The Receiver does not bind himself to accept the highest or any Tender.

All information may be had from Messrs. Ryland, Martineau & Co., Solicitors, 7, Cannon Street; Messrs. Hewitt, Chapman & Co., Accountants, 77, Colmore Row; or (with orders to view) from TRUBSHAW & TAYLOR, Auctioneers and Valuers, 1, Newhall Street, all of Birmingham. R 609

APPOINTMENTS OPEN.

THE UNIVERSITY OF SHEFFIELD.

FACULTY OF ENGINEERING.

Applications are Invited for

the POST of ASSISTANT LECTURER IN MECHANICAL ENGINEERING.

Salary £400 per annum, including evening work during Winter Session. Candidates holding a University Degree with Honours in Mechanical Science preferred.

Applications, stating particulars of training and experience, accompanied by three testimonials, should be sent not later than August 20th to the undersigned.

W. M. GIBBONS,
Registrar. R 529

The DIRECTORS of an AEROPLANE MANUFACTURING COMPANY are prepared to receive

Applications for the Post of

CHIEF of the DESIGN and DRAWING OFFICE. Applicants must have successfully filled a similar position and have had good experience. All applications will be treated with the strictest confidence and must give full details of experience, age, salary required and earliest date new post could be taken up.—Write BOX F.A.R., c/o Davies and Co., 95, Bishopsgate, E.C. 2. R 511

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LEYTON TECHNICAL INSTITUTE.

Wanted, a Workshop In-

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Commencing Salary from £350 to £300, according to experience and qualifications.

Experience of modern engineering works in fitting, turning, grinding, &c., essential. Work in a modern tool room, together with some teaching experience an advantage.

Applications to be returned not later than 15th August.

For Form of Application, send stamped addressed envelope to—

R. J. GELDART, R 588
Clerk to the Governors,
Town Hall, Leyton, E. 10.

CITY & GUILDS (ENGINEERING) COLLEGE.

There is a Vacancy in the

Mechanical Engineering Department for a DRAUGHTSMAN with special experience in the design of locomotives and internal combustion engines. Salary £250 per ann. Applications, stating age, technical education and experience, should be made in the first instance, to Prof. W. E. DALBY, F.R.S., City and Guilds (Engineering) College, Exhibition Road, S.W. 7, by August 3rd. R 601

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.

The College Committee will

shortly APPOINT an ASSISTANT to the Chadwick Professor of Municipal Engineering (Mr. M. T. M. Ormsby). Commencing salary £300. University training and some experience in Municipal Engineering required.

For duties, &c., apply to—
WALTER W. SETON, M.A., D. Lit.,
Secretary,
University College, London
(Gower Street, W.C. 1). R 563

CITY AND GUILDS (ENGINEERING) COLLEGE.

There are Two Vacancies in

the Mechanical Engineering Department for DEMONSTRATORS in Engineering Science. Salary £300.—Apply in the first instance to Professor W. E. DALBY, F.R.S., City and Guilds (Engineering) College, Exhibition Road, London, S.W. 7, before Wednesday, August 3rd. R 596

SALFORD EDUCATION COMMITTEE.

ROYAL TECHNICAL COLLEGE.

Principal: B. Prentice, D.Sc., Ph.D.

Required in September next,

ASSISTANT LECTURER in Physics and Electrical Engineering. Salary according to qualifications and experience. Further particulars and forms of application may be obtained from the undersigned.

R. MARTIN,
Secretary.

Education Office,
Salford. R 599

Research Department,
ROYAL ARSENAL, WOOLWICH.

DIRECTORATE OF METALLURGICAL RESEARCH JUNIOR ASSISTANT.

Required, One Metal-

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Initial salary £100 and bonus. (Total emoluments at present £382 19s. 0d.).

Annual leave, 24 days.

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MINISTRY OF EDUCATION, EGYPT.

DEPARTMENT OF TECHNICAL, INDUSTRIAL AND COMMERCIAL EDUCATION, CAIRO.

Applications are Invited for

the POST of PRINCIPAL of the SCHOOL OF ENGINEERING, Giseh (a Higher College), which will be vacant from October 1st next.

High academic and professional qualifications, together with responsible University and professional experience are desired.

The salary proposed is £E. 1200 to £E. 1440 with free residence, but the Selection Committee will be prepared to recommend an increase on this for an exceptionally qualified and experienced candidate.

Before making formal application, intending applicants should obtain from G. HLLIOT, Esq., Director, Egyptian Educational Mission, 28, Victoria Street, London, S.W. 1, a copy of the Note giving further particulars of the position together with instructions for applying.

July 1st, 1921. R 497

ROYAL NAVY.

Applications are Invited

for APPOINTMENTS as INSTRUCTOR LIEUTENANTS in the Royal Navy.

Candidates must be under 30 years of age, have had a University Training, and have taken an Honours Degree in Mathematics, Science or Engineering.

Present rates of pay are from £385 per annum on entry to a maximum of £949 per annum as Instructor Commander. Promotion by selection, to Instructor Captain is also open, with a maximum of £1,377 per annum.

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Service Victualling, cabin accommodation and servant are provided.

In cases where it is not possible to provide these the following allowances are paid in lieu:—

VICTUALLING ALLOWANCE	£80 per annum.
LODGING ALLOWANCE	£30 to £100 per annum according to Rank.
SERVANT ALLOWANCE	£20 to £60 per annum according to Rank.

For further particulars apply in the first instance to:—

THE SECRETARY OF THE ADMIRALTY,
Whitehall, S.W.1
R 444

Assistant Engineer Required

for London office of provincial firm. Must possess technical and commercial knowledge and potential selling power. The salary offered is moderate, but to a man possessing the necessary energy and ability the position has wide scope. Full particulars of education, training and experience, also salary asked.—Address, R 544, Offices of Engineering.

SOUTH INDIAN RAILWAY COMPANY, LIMITED.

Applications are Invited from

duly qualified Candidates for several Vacancies for ASSISTANT ENGINEERS on the Company's Staff in India.

Candidates, who may be between the ages of 24 and 30 years, must have received a sound general and technical education, followed by pupilage with a civil engineer engaged on construction work, or as engineer to a British Railway Company. Candidates must have also passed the Associate Membership Examination of the Institution of Civil Engineers, or have taken a degree exempting from such examination. One of the vacancies is for an Officer in Charge of the Drawing Office. Candidates for which should in addition have had a sound training in a drawing office and be a capable mathematician. The terms of the appointments are a three years' agreement in the first instance, commencing on a salary of 450 rupees per mensem and rising by annual increments of 50 rupees per mensem for each year of approved service to 900 rupees in the eighth year. The Company will provide a first-class passage to India, and the salary will commence from the date of sailing.

Preference will be given to Candidates who have had Railway experience or who have served during the late War.

Applicants must give a full chronological record of their career, stating whether they are married or single, including details of their education, training and subsequent civil or military experience, and state for which appointment they apply.

Applications must be addressed to the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, 3, Victoria Street, Westminster, S.W. 1. R 589

ROYAL SCHOOL OF MINES, FRECHEVILLE RESEARCH FELLOWSHIPS.

The Imperial College of

SCIENCE AND TECHNOLOGY, South Kensington, London, S.W.7., with which the Royal School of Mines is incorporated, is OFFERING TWO RESEARCH FELLOWSHIPS, of £300 a year each, tenable for one year and possibly renewable for a second year, to aid in carrying out any investigation or research connected with Mining, Mining Geology, Metallurgy, or the Technology of Oil, which in the opinion of the Selection Committee is of sufficient use or promise.

Applicants who may be Associates of the Royal School of Mines or others, and preferably men with some practical experience, should apply in writing to the SECRETARY of the College (from whom further particulars may be obtained), before 1st September, 1921, giving the nature of the proposed investigation, qualifications for the work and references.

It is anticipated that the Committee will make the awards by the end of November, so that the Fellowships and work may begin on 1st January, 1922. Holders will be expected to devote their whole time to the work which may be conducted at the Imperial College or in special circumstances elsewhere at the discretion of the Committee. R 409

LONDON COUNTY COUNCIL.

Required in September next,

to the under-mentioned TEACHING STAFF:—
PERMANENT WHOLE-TIME TEACHERS.

PADDINGTON TECHNICAL INSTITUTE, Saltram Crescent, W.

Engineering.—A good Honours University degree or its equivalent is essential, except in the case of applicants otherwise exceptionally qualified. Salary £325–£315, according to experience and qualifications, rising by annual increments of £15 to £390 a year and thence by annual increments of £10 to £440 a year.

SCHOOL OF ENGINEERING AND NAVIGATION, High Street, Poplar, E.

Workshop Instructor.—Training and experience in Engineering work essential. Teaching experience desirable. Salary £275–£325 a year, according to experience, rising by annual increments of £10 to £340 a year.

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Engineering Subjects.—Three attendances a week. A thorough knowledge of mechanics and mathematics as applied to Engineering and ability to Lecture and take Laboratory work essential.

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Engineering Workshop Practice.—One for two and one for three attendances a week. Good all-round experience of fitting turning, grinding, &c., essential, and a knowledge of all modern precision machinery.

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Motor Car Engineering (Assistant).—One attendance a week. Experience in the design and manufacture of Cars essential.

The fee for Visiting Teachers is 15s. and for Assistants 10s. an attendance each of about three hours, subject to a temporary addition of 20 per cent. conditionally and to revision on issue of Burnham Award.

Preference given to candidates who have served or attempted to serve with H.M. Forces.—Apply to Education Officer (T. 1a), Education Offices, Victoria Embankment, W.C. 2 (stamped addressed foolscap envelope necessary), for form of particulars, to be returned by Eleven a.m. on 26th August, 1921. A separate form must be used for each position applied for. Canvassing disqualifies.

JAMES BIRD,
Clerk of the London County Council.
R 574

A CHART FOR THE DESIGN OF HELICAL WIRE SPRINGS.

By R. BROOKS, B.Sc. (Lond.).

IN many types of mechanism, such as switchgear and kindred automatic apparatus, helical springs perform numerous subsidiary but nevertheless important functions. The re-engagment of releasing latches is nearly always dependent upon the action of a spring and it is essential that the spring applied should not only perform its functions in the first instance, but should be so proportioned that it is not overstressed and, consequently, subject to rapid deterioration. The calculation of a spring to fulfil these conditions in each instance is tedious, especially where a large variety of apparatus demanding numerous sizes and types of springs has to be handled. The amount of information available for the designer's use in the various pocket-books is very extensive, but it is a matter of common experience that such information is not generally in a form suitable for rapid estimation of the proportions of a spring to meet any required conditions. In the following discussion expressions are developed on which diagrams are built up, and from these the complete proportions of a spring to meet any required specification can be determined with practically no calculation whatever. It is suggested that these diagrams on a large scale would be of great service in drawing offices where work of this type is being carried out, as their use would enable draughtsmen to proportion springs with certainty, and would avoid the cut and try methods which are, unfortunately, too often employed.

To meet completely the requirements of any given case, a spring must fulfil the following conditions :—

(1) The load-deflection characteristic must be suitable.

(2) The material must not be overstressed at the maximum deflection.

(3) The material must be fully utilised.

In connection with the third point it is evident that a light weight spring and a heavy weight spring may have the same load-deflection characteristic owing to their different proportions, but for the same total deflection if the light weight spring is stressed up to its safe limit the heavy weight spring will not be so highly stressed and, consequently, its material is not being fully utilised. Wire of round section is most generally employed and the discussion is, therefore, confined to this type, the materials considered being tempered steel, and phosphor bronze.

The constants used for the safe stress and the modulus of elasticity are average values for the above materials, and it will be seen that the modulus value used squares very well with the test results. It cannot be too strongly emphasised, however, that spring materials vary very greatly in their characteristics, and satisfactory results can only be relied upon when the physical constants of the material to be used have been carefully ascertained.

Only two materials are shown on the diagrams, but should a new material be employed having different constants, the addition of a single curve to each diagram is all that is necessary to make them suitable for use.

Numerous types of round wire spring are in use but the two following types are very commonly employed and the discussion of the subject will be limited to these :—

(*a*) Close coiled helical springs in tension.

(*b*) Helical springs in torsion.

For each of these groups a short table of test results is given contrasted with figures as calculated by means of the diagrams.

(*a*) *Close Coiled Helical Springs in Tension.*—In this case the wire may be considered subject to pure torsion so that, referring to Fig. 1

$$\text{Shear strain } \phi = \frac{r\theta}{l} = \frac{\theta d}{2l}$$

Let f_s = maximum shear stress.
N = modulus of rigidity.

Then shear strain also equals $\frac{f_s}{N}$

Equating this to the value first obtained we get—

$$\frac{f_s}{N} = \frac{\theta d}{2l} \text{ or } \theta = \frac{2 f_s l}{N d} \quad . \quad . \quad (1)$$

Now if the coiled spring be loaded gradually with a weight W as in Fig. 2 and the resulting extension is y, the work stored in the spring is obviously $\frac{1}{2} W y$ and this may therefore be equated to the torsional resilience of the wire which is expressed by $\frac{1}{2} T \theta$ where T is the torque applied and θ is the angle through which one end of the wire turns relatively to the other.

Hence

$$\tfrac{1}{2} T \theta = \tfrac{1}{2} W y$$

or

$$y = \frac{T \theta}{W}$$

Fig. 1.

Fig. 2.

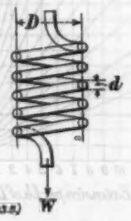


Fig. 3. HELICAL SPRINGS IN TENSION.

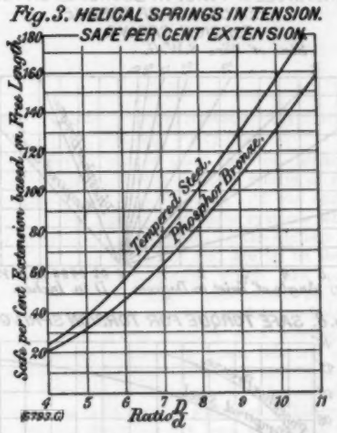


Fig. 4.

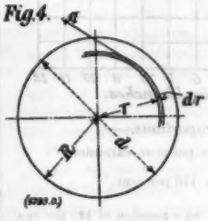


Fig. 6.

Now from Fig. 2.

$$T = \frac{W D}{2}$$

Hence

$$y = \frac{W D}{2} \cdot \frac{\theta}{W} = \frac{\theta D}{2} \quad . \quad . \quad . \quad (2)$$

Substituting in (2) the value of θ given in equation (1) we obtain

$$y = \frac{2 f_s l}{N d} \times \frac{D}{2} = \frac{f_s l D}{N d}$$

Also l, the length of wire in the spring $= \pi D n$ where n is the number of turns.

Hence

$$y = \frac{\pi D^2 f_s n}{N d}$$

Now y is the total extension of the whole coil for a maximum stress f_s in the material, and since the axial length of the coil is given by the product of $n \times d$ we have

Percentage extension of coil

$$= \frac{y}{n d} \times 100$$

$$= \frac{\pi D^2 f_s n}{N d} \times \frac{100}{n d}$$

$$= \frac{100 \pi D^2 f_s}{N d^2} \quad . \quad . \quad . \quad (3)$$

If we take for f_s a value which is a safe working stress for the material and insert the numerical constants we shall get for each material an expression for the safe percentage extension of the form $y_1 = K\left(\frac{D}{d}\right)^2$.

This result shows that the safe percentage extension of any close coiled spring of a given material depends only on the physical constants and the ratio $\left(\frac{D}{d}\right)^2$ *i.e.*,

$$\left(\frac{\text{Mean diameter of coil}}{\text{Diameter of wire}}\right)^2$$

For the two materials considered in this discussion the constants are as follows :—

Material.	Safe Shear Stress (f_s) in Lbs. per Sq. In.	Modulus of Rigidity (N) Lbs. per Sq. In.
Tempered steel...	60,000	12×10^6
Phosphor-bronze	25,000	6×10^6

Inserting these constants in the expression obtained we get :

For tempered steel

$$K = \frac{100 \times \pi \times 60{,}000}{12 \times 10^6} = 1{\cdot}57 \text{ and } y = 1{\cdot}57\left(\frac{D}{d}\right)^2$$

For phosphor bronze

$$K = \frac{100 \times \pi \times 25{,}000}{6 \times 10^6} = 1{\cdot}31 \text{ and } y = 1{\cdot}31\left(\frac{D}{d}\right)^2$$

These results are set out in the diagram in Fig. 3, the percentage extension being plotted against the ratio $\frac{D}{d}$ up to values of 11 to 1. It will be seen that for high values of $\frac{D}{d}$ the permissible percentage extension is very great, while for values less than about 4 the safe extension is very low indeed. It is desirable to call attention to this point as the fact does not seem to be generally recognised. It is quite common to find men working to some rough rule such as "maximum extension should not exceed 50 per cent. of the initial length," a method which is not only crude but leads in some cases to dangerous overstress. To complete the data required for determining the proportions of a spring for a given purpose it is necessary to obtain an expression in terms of dimensions and material constants for the actual percentage extension per pound of load and this may be done as follows :—

Actual Percentage Extension per lb. of Load.—Fig. 4 shows a section of wire which is subjected to pure torsion, and in this case we have the following conditions :—

Total shear stress (Q) in the elemental ring

$$= q \times 2 \pi r \, dr.$$

Now shear stress is proportional to shear strain

$$\therefore q = f_s \frac{r}{R} \text{ where } f_s \text{ is the maximum skin stress.}$$

whence

$$Q = 2 \pi \frac{f_s}{R} \cdot r^2 \cdot dr.$$

The torque of this about the axis is $d\,T = Q\,r$.

Total torque

$$T = \Sigma Q r = \int_0^R 2 \pi \frac{f_s}{R} \cdot r^3 \, dr$$

$$= \frac{\pi}{2} \cdot f_s \cdot R^3$$

or

$$f_s = \frac{2T}{\pi R^3} = \frac{16\,T}{\pi d^3} \text{ where } d = \text{diameter of wire.}$$

Now again equating torsional resilience and work done as before we had

$$y = \frac{f_s l D}{N d}$$

and substituting the value obtained above for f_s and putting $\pi D n$ for l and $\frac{W D}{2}$ for T we get

$$y = \frac{16\,T}{\pi d^3} \cdot \frac{\pi D^2 n}{N d} = \frac{8\,W D^3 n}{N d^4},$$

which is the standard expression usually employed. The percentage extension per lb. of load W will

therefore be ($n\,d$ being the axial length of the coil)

$$\frac{y}{n\,d} \times \frac{100}{W} = \frac{8\,W\,D^3\,n}{N\,d^4} \times \frac{100}{n\,d\,W} = \frac{800\,D^3}{N\,d^5}.$$

It is evident from this result what we cannot obtain a single curve connecting percentage extension and ratio $\frac{D}{d}$ in this case, since the indices of D and d are not the same. We can write the expression, however, in the following form, putting Y_2 for the percentage extension per lb. of load.

$$Y_2 = \frac{800\,D^3}{N\,d^5}$$

or

$$Y_2\,d^2 = \frac{800}{N}\left(\frac{D}{d}\right)^3 \quad . \quad . \quad . \quad . \quad . \quad (4)$$

The right-hand side of this equation can be shown as a single curve plotted against values of Y_2d^2, and if we divide the values of the latter by d^2 for each size of wire we obtain a number of diagonal lines which enable us to read off the corresponding values of Y_2 for any size of wire.

This is done in Fig. 5 and this diagram, in conjunction with Fig. 3, provides all the data necessary to determine the proportions of any spring within the range of sizes included on the chart.

Inserting values in equation (4) we obtain the following figures for the right-hand side—

For Tempered Steel—

$$Y_2\,d^2 = \frac{800}{12 \times 10^6}\left(\frac{D}{d}\right)^3 = 6{\cdot}66 \times 10^{-5}\left(\frac{D}{d}\right)^3$$

For Phosphor Bronze—

$$Y_2\,d^2 = \frac{800}{6 \times 10^6}\left(\frac{D}{d}\right)^3 = 13{\cdot}33 \times 10^{-5}\left(\frac{D}{d}\right)^3$$

and these values are utilised in the construction of Fig. 5.

The method of using the diagrams is illustrated in the following examples.

1. *To Determine the Characteristics of any given Spring whose Dimensions and Material are known.*—*Example.*—A tempered steel spring has the following dimensions :—

Mean diameter of coil (D) = $\frac{13}{16}$ in. (·812 in.)
Diameter of wire (d) = ·116 (No. 11 S.W.G.)
Initial length of coil = 8·25 in.
Effective number of turns = 70

It is required to determine for the above spring :—

(*a*) The maximum safe load.
(*b*) The maximum extension.
(*c*) The load extension characteristic in lbs. per inch.

The method adopted is as follows :—

(1) $\frac{D}{d} = \frac{·812}{·116} = 7$

(2) Safe per cent. extension (from Fig. 3) for $\frac{D}{d} = 7$ is 78 per cent.

$$\therefore \text{extension in inches} = \frac{78}{100} \times 8{\cdot}25 = 6{\cdot}4 \text{ inches.}$$

(3) From Fig. 5 take a line from $\frac{D}{d} = 7$ up to the "Steel" curve, thence horizontally to the diagonal for 11 S.W.G. and below this read off

Y_2 (per cent. extension per lb.) = 1·7 per cent.

(4) The per cent. extension for the full load being 78 per cent. we have

$$\text{Maximum safe load} = \frac{78}{1{\cdot}7} = 46 \text{ lbs.}$$

(5) The load per inch extension $= \frac{\text{Max. load}}{\text{Max. extension}}$

$$= \frac{46}{6{\cdot}4} = 7{\cdot}2 \text{ lbs. per inch.}$$

Test Result.—A careful test of a spring having the above dimensions gave the following value which corresponds closely with the above calculated figure, the difference being only 2·5 per cent.

Test load per inch extension = 7·4 lbs.

2. *Predetermination of the proportions of a Spring.*—The specification for a spring includes the following points in addition to the material :—

(1) The initial length when unloaded.
(2) The extended length loaded.
(3) The load to be carried at the extended length.

These conditions are determined by the work the spring has to do and from the design and proportions of the apparatus on which it is to be used.

With regard to the outside diameter it is usual to specify a limiting maximum, but it will be clear that the possibility of adhering to such a condition is dependent on the other factors in the case, and as much latitude as possible should be allowed.

It may be pointed out, however, that the method of calculation here described results in a spring of the minimum safe dimensions, and means must be provided in the design of the apparatus for accommodating a spring of at least these dimensions.

Suppose we have then a specification as follows :—

Material ... ... Tempered Steel.
(*a*) Initial length ... 4·5 in. (over coils only, not including ends).
(*b*) Extended length ... 9·5 in. over coils only, not including ends).
(*c*) Load extended ... 33 lbs.

Fig. 5.

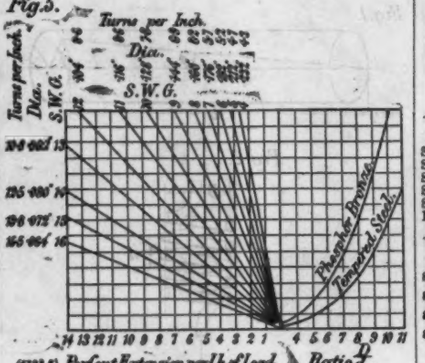

Turns per Inch.
Dia.
S.W.G.
Turns per Inch.
Dia.
S.W.G.
Phosphor Bronze.
Tempered Steel.
14 13 12 11 10 9 8 7 6 5 4 3 2 1 4 5 6 7 8 9 10 11
Per Cent Extension per Lb of Load.
Ratio $\frac{D}{d}$.

Fig. 7. ANGLE OF TWIST IN DEGREES PER TURN PER LB. INCH OF TORQUE. TORSION SPRING.

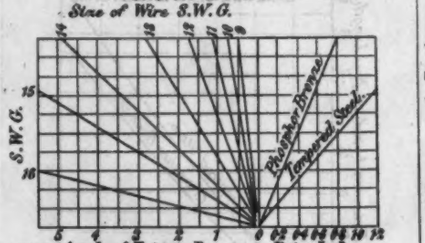
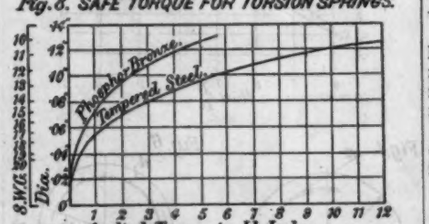


Fig. 8. SAFE TORQUE FOR TORSION SPRINGS.


10 11 12 13 14 15 16 18 20 22 24 26 28 30
Phosphor Bronze.
Tempered Steel.
S.W.G.
Dia.
0 1 2 3 4 5 6 7 8 9 10 11 12
Applied Torque in Lb. Inches.

Method of determining Proportions.—

(1) From (*a*) and (*b*) we have per cent. extension

$$= \frac{9{\cdot}5 - 4{\cdot}5}{4{\cdot}5} = 110 \text{ per cent.}$$

(2) Reference to Fig. 3 for an extension of 110 per cent. gives a ratio $\frac{D}{d} = 8{\cdot}3$ for Steel.

(3) Per cent. extension per lb. $= \frac{110}{33} = 3{\cdot}33$ per cent.

(4) From Fig. 5 for $\frac{D}{d} = 8{\cdot}3$ and extension 3·33 per cent. we find the size of the wire to be 12 S.W.G. (·104 in.) having 9·6 turns per inch (close wound).

The spring required can therefore be dimensioned as follows :—

Turns = 4·5 × 9·6 = 43
Size of wire = 12 S.W.G. = 0·104 in. diam.
Mean diameter = 8·4 × 0·104 = 0·875 in.

Test Results.—As a check on the above, a spring was made up to these dimensions and tested with the following results :—

Load per inch extension = 6·5 lb.
Load for 5 in. extension = 5 × 6·5 = 32·5 lb.

This compares closely with the specified value of the load, viz., 33 lbs.

The following table gives particulars of the calculated and tested values for a number of springs of steel and phosphor bronze, and it will be seen that there is very close correspondence in the results. Some of the discrepancies are probably due to the difficulty of measuring quite accurately the mean diameter of the coil, and variations in the material and diameter of the wire must also be allowed for.

Table of Helical Springs. Calculated and Test Values.

Material.	Number of Turns.	Free Length.	D	d.	Gauge of Wire. S.W.G.	$\frac{D}{d}$	Calculated. Percentage Extension per Lb.	Calculated. Lbs. per Inch Extension.	Tested Lb. per Inch. Extension.
		in.	in.	in.					
Steel	70	8·25	·812	·116	11	7·0	1·7	7·2	7·4
Steel	43	2·75	·625	·064	16	9·75	13·7	2·6	2·5
Steel	18	1·9	·74	·104	12	7·12	2·1	25·4	24·5
Steel	24	2·21	·69	·092	13	7·5	3·0	14·5	14·0
Steel	43	4·5	·875	·104	12	8·4	3·3	6·6	6·5
Phosphor bronze..	25	2·3	·625	·092	13	6·8	4·4	9·85	9·8

(*b*) *Helical Springs in Torsion.*—Here the wire is subjected to a bending moment due to the load applied at the end of the lever. As the point of application will vary in different cases the diagrams are worked out in terms of torque in pound inches.

The action of winding up the spring reduces the radius of curvature of the helix, and hence we may apply the ordinary equations applicable to beams.

Referring to Fig. 6, page 173, we have :—

Bending moment at P

$$= E\,I \times \frac{1}{R}$$

where I is the transverse moment of inertia of the section of the wire and $\frac{1}{R}$ is the change of curvature between P and Q.

Multiplying each side by P Q we get :—

$$M\,d\,l = \frac{E\,I}{R} \cdot R\,d\,\theta$$

and integrating both sides we have for the whole angle θ through which the spring is twisted :—

$$M\,l = E\,I\,\theta$$

$$\therefore \theta = \frac{M\,l}{E\,I}$$

where l is the total length of wire in the spring.

In applying a spring of this type, the maximum length of the helix is generally determined by the mechanism while the diameter may vary within fairly wide limits, though there is generally a minimum limit.

It will be convenient to adopt as a unit for the diagram, the degrees of twist per turn of the helix for 1 lb. inch of applied torque.

For the whole spring we already have :—

$$\theta \text{ (radians)} = \frac{M\,l}{E\,I}$$

Now

$$I = \frac{\pi\,d^4}{64} \quad \text{and} \quad l = \pi\,D\,n$$

where n is the number of turns in the helix.

$\therefore$ $\theta°$ per lb.-in. torque per turn

$$= \frac{1 \times l \times 180}{E\,I \times \pi\,n} = \frac{\pi\,D\,n \times 64 \times 180}{E \times n \times \pi\,d^4 \times \pi}$$

$$= \frac{64\,D}{E\,d^4} \times \frac{180}{\pi}$$

Writing this

$$\theta\,d^4 = K \cdot \frac{64}{E} D$$

we get an equation of a form similar to that obtained for tension springs and from which a diagram of the same type can be plotted (see Fig. 7).

Safe Value of Applied Torque.—The applied torque being M and the moment of resistance of the section

$$\frac{\pi\,d^3\,f_t}{32}$$

we have

$$\text{Safe M} = \frac{\pi\,d^3\,f_t}{32}$$

where f is the safe value of the stress in the material. The size of wire may therefore be deduced directly from the torque, and the curves in Fig. 8 give values for steel and phosphor bronze. The safe stress and

modulus figures for bending which are used in the preparation of Figs. 7 and 8 are as follows :—

	Safe Stress in Lb. per Sq. In.	E. Lb. per Sq. In.
Tempered steel ...	60,000	30×10^6
Phosphor bronze ...	25,000	15×10^6

Inserting these values in the equations obtained above we get,

For Fig. 7 :—

Steel—

$$\theta^\circ = \frac{180}{\pi d^4} \cdot \frac{64}{30 \times 10^6} D = \frac{1}{d^4} (122 \times 10^{-6}) D$$

Phosphor bronze—

$$\theta^\circ = \frac{180}{\pi d^4} \cdot \frac{64}{15 \times 10} D = \frac{1}{d^4} (244 \times 10^{-6}) D$$

For Fig. 8 :—

Steel—

$$\text{Safe } M = \frac{\pi \times 60000}{32} d^3 = 5880\ d^3$$

Phosphor bronze—

$$\text{Safe } M = \frac{\pi \times 25000}{32} d^3 = 2450\ d^3$$

The following examples indicate the method of using Figs. 7 and 8.

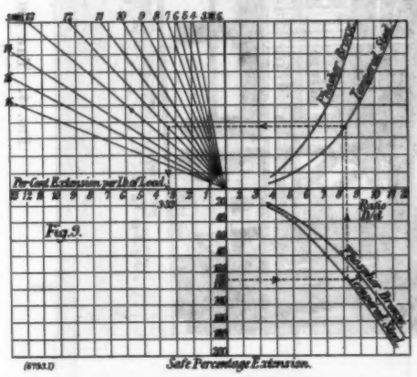


Fig. 9.

Example 1.—A steel spring is required to the following specification :—

Length of helix (close coiled) ...	4·5 in.
Minimum inside diameter of helix ...	$\frac{5}{8}$ in.
Maximum torque	6·4 lb. in.
Maximum angle of twist	260°

From Fig. 8.—

Size of wire = 12 S.W.G = ·104 in. diameter.

$$\text{Number of turns} = \frac{4 \cdot 5}{0 \cdot 104} = 43$$

$$\therefore \theta^\circ \text{ per turn per lb. in. of torque} = \frac{260}{43 \times 6 \cdot 4} = \cdot 94^\circ$$

From Fig. 7.—For ·94 deg. we get D = 0·88 in., say, $\frac{7}{8}$ in. This gives an internal diameter of 0·875 − 0·104 = 0·771 in., which is well clear of the 0·625 in. minimum specified.

The spring may therefore be proportioned thus—

43 turns close wound.
12 S.W.G. tempered steel wire.
Mean diameter $\frac{7}{8}$ in.

Test Result.—A spring made up as above required for a complete revolution (360 deg.) a torque of 8·8 lb. in.

$$\text{For } 260^\circ \text{ the torque} = \frac{260}{360} \times 8 \cdot 8 = 6 \cdot 36 \text{ lb. in. as}$$

compared with 6·4 lbs. inches specified.

The above method gives a spring with the maximum number of turns for the length of helix. It may be found however, that this gives a mean diameter of coil less than the minimum specified. In such a case the correction is easily made as follows :—

In the above example let the minimum specified diameter be $\frac{7}{8}$-in. Evidently the spring as above designed is not suitable. A mean diameter of 1 in. would suit, and referring to Fig. 7 we find that for D = 1 in. and 12 S.W.G. wire θ = 1·05 deg. per turn per lb. in.

As the total twist is 260 deg. we have

$$\text{Number of turns } \frac{260}{1 \cdot 05 \times 6 \cdot 4} = 30.$$

Example 2.—Required to determine the characteristics of the following spring :—

25 turns
13 S.W.G. = ·092 in. phosphor bronze
Mean diameter = ·625 in.

From Fig. 7.—For D = 0·625 and 13 S.W.G. phosphor bronze we find θ = 2·1 deg. per turn per pound inch torque.

On testing the spring it was found that a torque of 6·6 lb. in. gave a twist of 360 deg.

$$\therefore \theta \text{ per turn per lb. in. of torque} = \frac{360}{6 \cdot 6 \times 25} = 2 \cdot 18^\circ$$

which compares very well with 2·1 calculated.

The following table gives particulars of calculated and test results for a number of springs :—

Material.	D.	d.	Gauge of Wire. S.W.G.	Per Turn per Lb. Inch Torque.		No. of Turns.
				Calculated.	Test Result.	
	in.	in.				
Steel ..	·5	·104	12	·52	·515	20
Steel ..	·875	·104	12	·94	·95	43
Steel ..	·375	·048	18	8·65	8·80	25
Phosphor bronze..	·625	·092	25	2·10	2·18	25

The usefulness of the tension spring charts may be improved by combining diagrams 3 and 5 into one chart as indicated in Fig. 9 annexed. The dotted line indicates the steps to be taken in determining the proportions of the spring investigated in paragraph (2).

Starting from the point 110 per cent. on the downward vertical axis follow across to the "steel" curve, thence vertically to the upper section "steel" curve and then across to the left to a point above the "per cent. extension per lb. of load = 3·33 per cent." where we obtain at once the size of wire and turns per inch.

THE SMITH CONTINUOUS CARBONISATION PROCESS.

THERE has been a good deal of discussion of recent years as to the relative merits of different systems of coal carbonisation. At one end of the scale are the high-temperature systems which are usually chosen from a desire for the highest possible gas yield. At the other end are to be found the low-temperature methods which are primarily concerned with a larger production of valuable liquid distillates, and of a useful smokeless fuel. As was pointed out recently at a meeting of the Royal Society of Arts the exact relative economy of these processes depends upon a number of factors which have somewhat unstable values, and in this country, at least so far, sufficient improvement in the balance sheet has not been shown for the low-temperature process to become a very formidable rival of the other. The question turns largely on the form in which the products are best marketable, and if the markets change so as to make a smokeless fuel the chief interest of the carbonising companies and the production of fuel oil of importance in supplementing diminishing imported supplies, the low-temperature method may come into its own.

Where gas of itself is not the first consideration other systems undoubtedly can advance good claims to attention, owing to the value of the low-temperature by-products. One such system which has, we understand, now been in use on a fairly large scale in the United States for two years, is the Smith continuous system of carbonisation, which is in reality a dual process. This system was recently described in a paper read before the Society of Chemical Industry, by Mr. G. H. Thurston, to whom we are now indebted for the particulars and illustrations contained in the following account of the process.

The Smith process is, as stated, a dual process, the coal being first subjected to low-temperature distillation, after which the solid residue is again treated at high temperature to produce a hard fuel known commercially as "Carbocoal." The process is named after Mr. C. H. Smith, New York, the inventor, and plants working on the system are now producing 550 tons of carbocoal daily. A plant at Irvington, New Jersey, has been in steady work for two years, while our illustrations are of a plant at Clinchfield, Va., the property of the International Coal Products Corporation of Virginia, who are working the Smith process. This plant has a capacity of 150,000 tons per annum. A general view of the plant is given in Fig. 1, page 176. The remaining figures on pages 176 and 177 will be referred to as we proceed with the description.

The plant is completely equipped with labour-saving devices. The coal is delivered from the railway cars into a low-level hopper or bin, from which it is carried by a belt conveyor to a crusher. This machine reduces it to about $\frac{3}{4}$-in. size, in which state it is elevated to a bucket conveyor to the top of the primary retort building. This building is shown in Fig. 2, and in section diagrammatically in Fig. 5, page 177. At the top of this building is a conveyor which feeds the bins supplying the primary retorts, as will be clear from Fig. 5. We may point out that in Fig. 2 the conveyor from the crusher to the top of the retort house is shown as a steep-enclosed trunk at the right-hand end of the building; the second, less steeply-inclined conveyor at this point will be referred to directly. The small coal is fed mechanically into the retorts at one end, and after being submitted to the distillation process is discharged at the other through a water seal. These retorts we shall deal with in greater detail.

The material on leaving the retorts consists of a friable spongy mass, which is next delivered by a conveyor running the length of the retort-house to the second inclined conveyor referred to above and shown in Fig. 2. This delivers the partly-coked material to the building on the extreme right of Fig. 2, containing storage bins, another crusher and a briquetting plant. Here the material is again crushed, to $\frac{1}{4}$-in. size, mixed with 8 per cent. to 10 per cent. of pitch, by weight, and stored. From this storage it is taken off to a fluxer, in which the pitch and solids are intimately mixed with the assistance of steam, being finally delivered to the briquetting press. The latter is of the roll type, and the product, in the form of egg-shaped briquettes of 3-oz. weight, is passed to a long conveyor shown in the view in Fig. 3. This conveyor is of such length that by the time the briquettes arrive at the end they are cooled off and set, and can be delivered to a storage bin in the second retort-house, an enlarged view of the latter being shown in Fig. 4. Here the briquetted material is subjected to a further carbonisation process at a high temperature, being delivered from the bin to the retorts by a hopper car. From these retorts another car runs the discharged briquettes of "carbocoal" off to a separate building where they are quenched and stored for distribution. The process is continuous, and as will be gathered from the foregoing is arranged on full labour-saving plans.

The two main features of this system are the primary and secondary retorts, the remainder of the plant, together with the by-product treatment plant being on well-recognised lines. The primary retorts are illustrated in Figs. 5 to 9, pages 177 and 178. The longitudinal and cross-sections given in Figs. 6 and 7 explain their working. These figures should be considered in connection with Fig. 5, which shows the method of coal supply from overhead hoppers, the discharge, the manner in which the gas is drawn off, the flue and recuperator systems, &c. The retort proper consists of a horizontal cylinder about 18 ft. in length and heart-shaped in cross-section. It is built up of blocks of carborundum fitted with tongued and grooved asbestos-packed expansion joints. Carborundum has been selected on account both of its heat-conducting and its high wearing qualities. The end walls are of firebrick, and built into them are housings for two longitudinal propeller shafts. These shafts are driven by gearing from the outside, and by means of paddles, work the coal, fed from the hopper, from one end of the retort to the other, during which time it is subjected to distillation at a temperature of about 480 deg. C. The paddles have a radius of 2 ft. 3 in. Fig. 8 shows the outside of the retorts at the discharge end, while Fig. 9 is a view of the driving gear, which, however, is slightly differently disposed from that diagrammatically depicted in Fig. 6. The paddle shafts in the retorts are 12 in. in diameter and the clearance between the end of the blades and the bottom of the retort is $\frac{3}{8}$ in. The shafts revolve at a speed of one revolution in 8 minutes, and the power taken is 2 brake horse-

THE SMITH PROCESS OF CONTINUOUS COAL CARBONISATION.

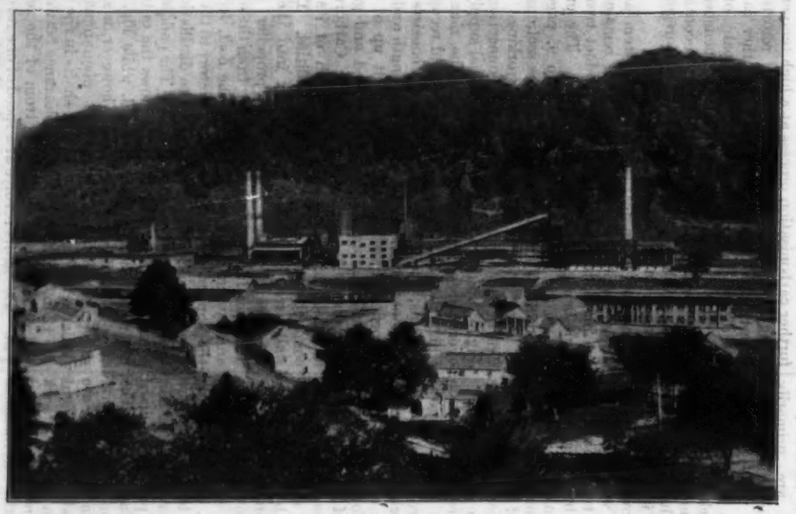


FIG. 1. GENERAL VIEW OF "CARBOCOAL" PLANT AT CLINCHFIELD, VA. U.S.A.

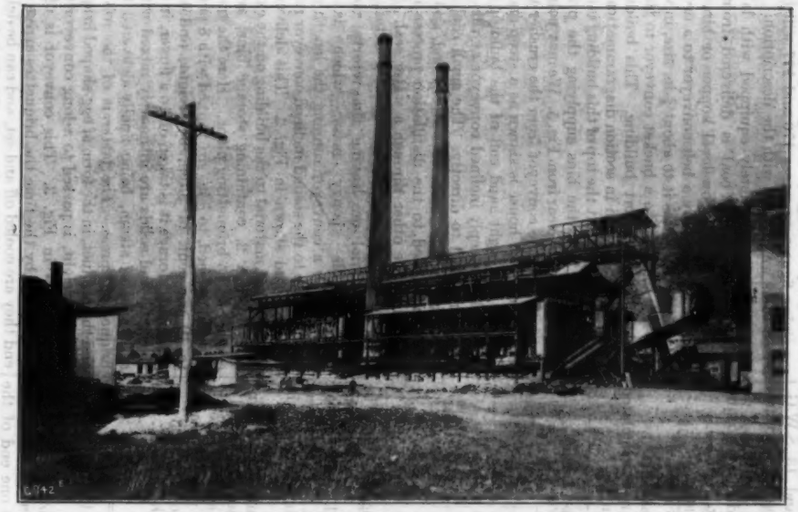


FIG. 2. THE PRIMARY RETORT BUILDING.

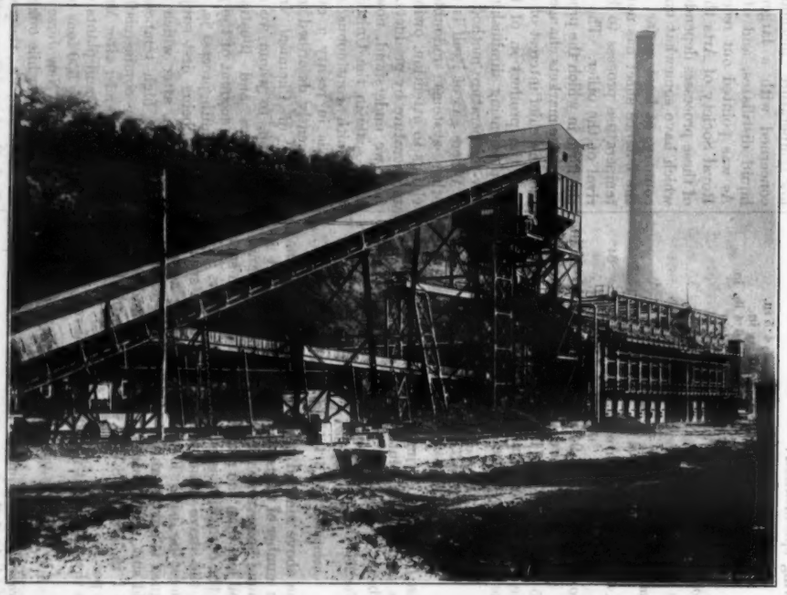


FIG. 3. THE CONVEYOR AND SECONDARY RETORT BUILDING.

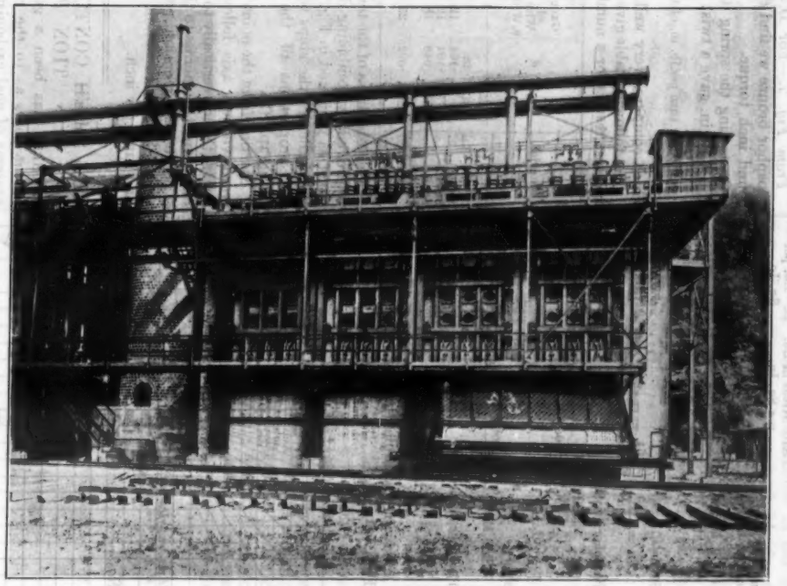
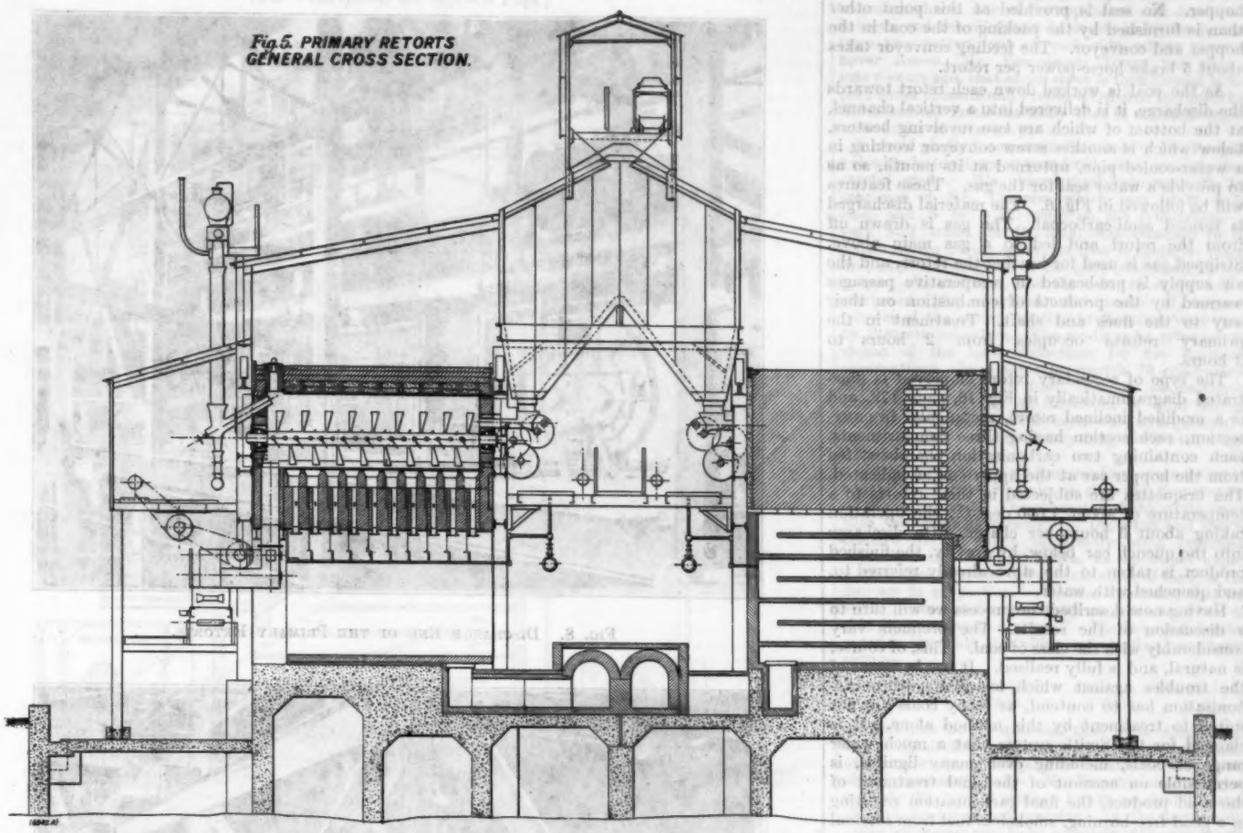
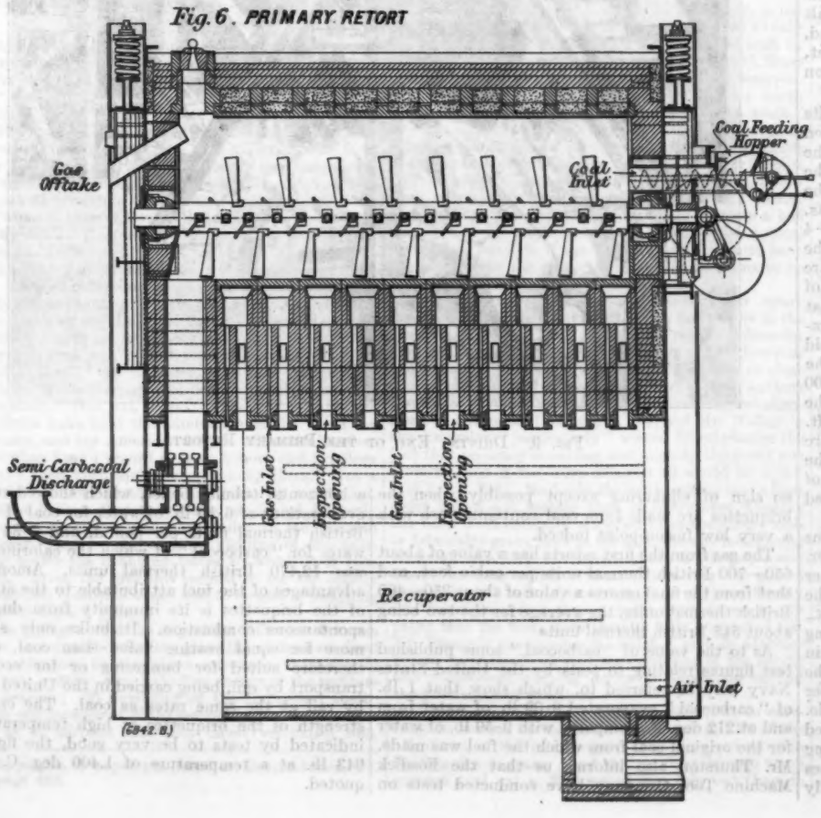
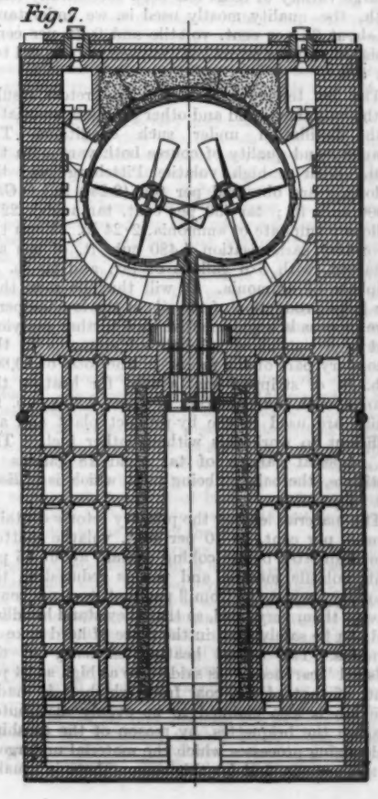


FIG. 4. THE SECONDARY RETORT BUILDING.

THE SMITH PROCESS OF CONTINUOUS COAL CARBONISATION.







power per retort. The retorts are kept about half full of material, feeding being arranged for by means of a screw conveyor in a pipe leading from the coal hopper. No seal is provided at this point other than is furnished by the packing of the coal in the hopper and conveyor. The feeding conveyor takes about 5 brake horse-power per retort.

As the coal is worked down each retort towards the discharge, it is delivered into a vertical channel, at the bottom of which are two revolving beaters, below which is another screw conveyor working in a water-cooled pipe, upturned at its mouth, so as to provide a water seal for the gas. These features will be followed in Fig. 6. The material discharged is termed semi-carbocoal. The gas is drawn off from the retort and led to a gas main above. Stripped gas is used for heating the retort, and the air supply is pre-heated in recuperative passages warmed by the products of combustion on their way to the flues and shaft. Treatment in the primary retorts occupies from 2 hours to 3 hours.

The type of secondary retort employed is illustrated diagrammatically in Fig. 10, page 179, and is a modified inclined retort, rectangular in cross-section, each section having three compartments, each containing two carbonisation chambers, fed from the hopper car at the upper end as indicated. The briquettes are subjected in these retorts to a temperature of about 1,090 deg. C., the operation taking about 6 hours per charge. On discharge into the quench car below, by gravity, the finished product is taken to the store already referred to, and quenched with water.

Having now described the process we will turn to a discussion of the results. The products vary considerably with the class of coal. This, of course, is natural, and is fully realised. It has been one of the troubles against which low-temperature carbonisation has to contend, as many coals are not suited to treatment by this method alone. It is claimed for the Smith system that a much wider range of coals, including even many lignites, is permissible on account of the dual treatment of the solid product, the final carbonisation resulting in a good free-burning, smokeless fuel from original coal which would be quite unsuitable for low-temperature treatment alone. In America, while a large variety of coals has been successfully dealt with, the quality mostly used is, we understand, of about 35 per cent. volatile and 0·72 per cent. moisture, when a retort has a capacity of about 1 ton per hour.

The low temperature of the first retort results in the valuable liquid and other products associated with distillation under such conditions. The quantity and quality of course both vary with the coal. With a high volatile Pittsburg coal the following are obtained per ton (2,240 lb.): Gas, 5,600 cub. ft.; tar (30 per cent. tar acids), 22·4 gallons; sulphate of ammonia, 2·24 lb. From the secondary carbonisation 4,480 cub. ft. of gas are obtained, with 5·6 gallons of tar, and 20 lb. of sulphate of ammonia. It will thus be seen that the large production of tar oils of the low-temperature process is supplemented by a further gas yield and high output of sulphate of ammonia in the secondary part of the process. The total of 10,800 cub. ft. of stripped gas is used for heating the retorts, with the exception of some 2,200 cub. ft. which are used in the by-product plant and are sufficient to work this without other fuel. The 28 Imperial gallons of tar yield 18 gallons of distillate, the balance being pitch which is utilised for briquetting.

The material leaving the primary retorts contains from 7 per cent. to 10 per cent. volatile matter. The briquettes before coking contain about 15 per cent. volatile matter, and this is reduced in the secondary retorts to from 3 per cent. to 4 per cent., leaving them very hard, so that they stand handling and can be safely used in the place of hard coke in furnaces. The actual heating efficiency of the finished "carbocoal" is said to be as high as 94 per cent. of that of the coal from which it is made. The ash is also claimed to be evenly distributed through the briquettes, by reason of the crushing and mixing processes which the material undergoes in the process, and for this reason there is usually no sign of clinkering except possibly when the briquettes are made from coal containing ash with a very low fusion-point indeed.

The gas from the first retorts has a value of about 650—700 British thermal units per cubic foot, and that from the final retorts a value of about 350—400 British thermal units, the average for the two being about 548 British thermal units.

As to the value of "carbocoal," some published test figures relating to tests by the United States Navy may be referred to, which show that 1 lb. of "carbocoal" evaporated 9·09 lb. of water from and at 212 deg. F., compared with 9·59 lb. of water for the original coal from which the fuel was made. Mr. Thurston also informs us that the Fosdick Machine Tool Company have conducted tests on a horizontal tubular boiler, which showed relative evaporations of 6·59 lb. of water for coal of 14,120 British thermal units per pound, and 7·34 lb. of water for "carbocoal" of which the calorific value was 12,470 British thermal units. Among the advantages of the fuel attributable to the strength of the briquettes is its immunity from dust and spontaneous combustion. It bulks only slightly more for equal heating value than coal, and is therefore suited for bunkering or for economic transport by rail, being carried in the United States by rail at the same rates as coal. The crushing strength of the briquettes at high temperature is indicated by tests to be very good, the figure of 943 lb. at a temperature of 1,400 deg. C. being quoted.

THE PROCESS OF CONTINUOUS COAL CARBONISATION.

FIG. 8. DISCHARGE END OF THE PRIMARY RETORTS.

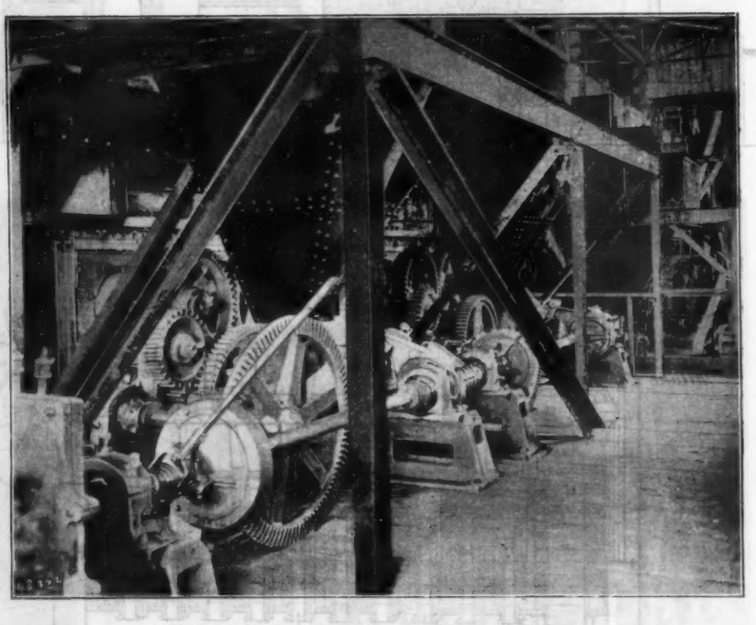
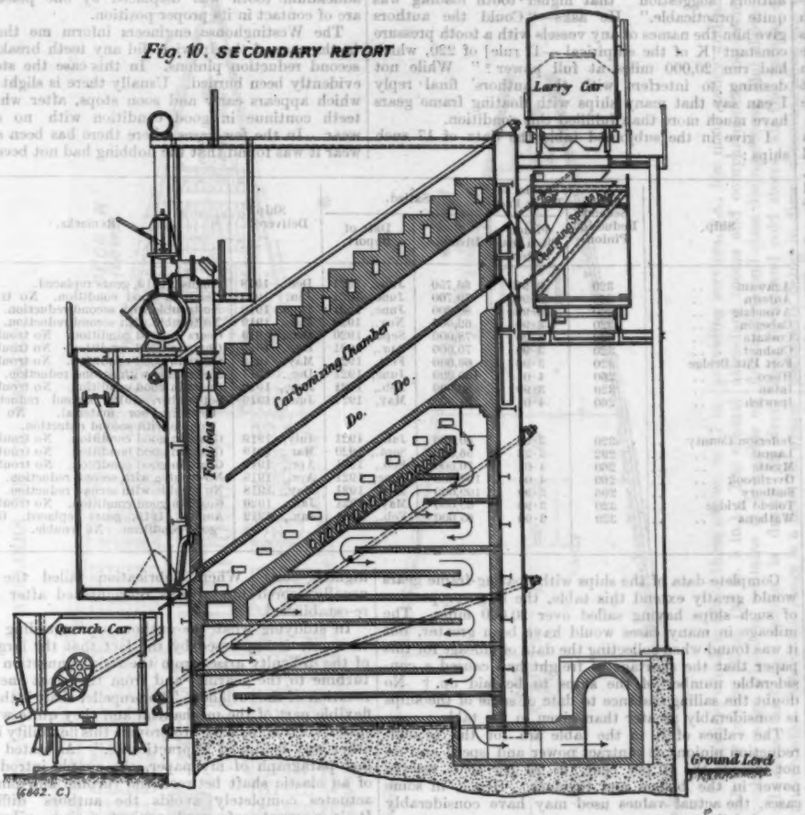


FIG. 9. DRIVING END OF THE PRIMARY RETORTS.

THE PROCESS OF CONTINUOUS COAL CARBONISATION.

(*For Description, see opposite Page.*)

Fig. 10. SECONDARY RETORT



MECHANICAL REDUCTION GEARS FOR WARSHIPS AND MERCHANT SHIPS.*

By JOHN H. MACALPINE.

SINCE writing the foregoing paper valuable evidence confirming my whole position has been published. This is contained in Messrs. Walker and Cook's paper on "Mechanical Gears of Double Reduction for Merchant Ships" (vol. cxi, p. 369) read before the Institution of Naval Architects in March, and in the discussion of their paper (vol. cxi, p. 347); also in a letter by Mr. S. K. French, general superintendent, Propulsion Machinery Department, American International Shipbuilding Corporation, entitled "A Plea for Proper Setting of Double Reduction Marine Gears," (see *Mechanical Engineering*, March, 1921, page 209).

Messrs. Walker and Cook's paper and its discussion give surprising evidence of how widespread the trouble with double reduction gears has been in Britain. Surely the authors exaggerate the gravity of the situation when they say that now "there are several double-reduction sets in actual service and running very satisfactorily" (vol. cxi, p. 369); and Admiral Goodwin remarks that "the experience of all the leading engineers in the country had been brought to bear on the problem" (vol. cxi, p. 347). The marine engineers of Britain have held the admiration of the world for a century, and my American friends will not misunderstand when I say I regard it as an honour and privilege to have been born and trained among them. Not a few I have known personally and many by reputation. I cannot believe that they have considered seriously a problem so simple and have failed to see the real difficulty—that is, the sensible yielding of the gear-casing under the changing forces to which it is subjected. From the first this seemed to me the plainly outstanding condition which had to be met in designing a good reduction gear.

If in trying to find the important difference between single- and double-reduction gears the authors confined their attention to the three questions they specify (vol. cxi, p. 369)—viz. "(1) The energy of the turbines and gearing; (2) flexibility of the [propeller] shaft; (3) the end movement of the secondary pinions"—there need be no surprise that they failed (vol. cxi, p. 369). The elasticity of the casing, which has large influence on the action of all "rigid" gears, but more on double- than single-reduction, as is shown in my paper, is not considered by them. This elasticity is referred to only twice; once in the paper (vol. cxi, p. 370) and once by Sir Charles A. Parsons (vol. cxi, p. 348), and both times with commendation which is entirely undeserved. There is no compensation possible for poor tooth cutting, and consequent "irregularities in the teeth," or other imperfect machining, as is suggested; and, as I have pointed out in previous writings, if the casing changes configuration by the action of the gear it must be from altered bearing pressures which, in turn, follow from changed distribution of tooth pressure: hence, such yield as are commended, infallibly indicate a bad distribution of tooth pressure. It would be a total reversal of function if the tooth pressure were to keep the bearings of the rigid casing in line, as seems to be expected.

Captain Onyon, R.N., "had investigated many breakdowns, but had never found the fault to lie in the design" (vol. cxi, p. 348). This I can readily believe for one would expect to find good design; but, however good the design of a rigid gear, maintenance of close enough alignment cannot be assured. The authors emphasise by italics the great importance of correct alignment in the paper (vol. cxi, p. 369) and Mr. Walker in the discussion "particularly" wished to emphasise the fact that accuracy in cutting and aligning the gears was essential, and if this were attained all would be well" (vol. cxi, p. 348). No doubt the tooth cutting is of a high order and I am certain that in every case aligning has been most carefully attended to in the shop—and, in Admiralty gears, later in the ship, thereby recognising its great reliability to change. But, as the paper and discussion bear ample evidence, it is very far indeed from being all well. Our anticipation of this difficulty was based on simple theory, but I have shown in my paper that the facts were thereby fully accounted for. Mr. French's measurements, which I give in abstract below, have demonstrated the springing of the casing and consequent varying errors of alignment beyond the possibility of question.

[I may note in passing that the difficulty, so carefully considered by the authors (vol. cxi, p. 370) of the alignment of the intermediate shaft does not exist in floating frame gears. And that, if the reference to oil grooves (vol. cxi, p. 370) means that they cut these in parts of the bearing metal which take pressure, they thereby only allow the oil to escape from regions of higher to those of lower pressure, to the great detriment of the bearing action. The bearing should consist of two unbroken sheets, one in the top brass and one in the bottom, and the oil should be drawn in by the journal from two gutters, one on each side, where pressure never comes. Mr. Beauchamp Tower has shown, many years ago, that an oil sheet is then formed in the part under pressure and Professor Osborne Reynolds has demonstrated mathematically that it is stable within wide limits of pressure.]

I would gladly incorporate the whole of Mr. French's valuable letter if space permitted, as it deserves most careful study. His observations were made on the gear-case of S.S. Carence, which was 12 ft. 4 in. long and 8 ft. 6 in. wide on the foundation. A very stiff tram, 14 ft. long, was attached to the centre of the casing cover, so that it could be placed first over one diagonal of the gear (starboard forward to port aft) and then over the other (port forward to starboard aft). Vertical movements of opposite corners of the casing relative to the tram were made by Starrett indicators. The readings he gives are the means of the total deflections for five successive observations. In a table he records 19 observations taken on the voyage from Glasgow to Baltimore. These are for nearly all directions of wind and sea relative to the ship, and from no wind to a gale and no sea to rough; and in a heavy long swell with a light wind.

For no wind or sea all four readings were 0·002 in., which Mr. French regards as showing the accuracy of the instrument. The character of the strain varied with the changing direction of the wind and the sea relative to the ship; apparently being principally dependent on that of the sea, as we would expect. "As the sea increases the deflectiveness of the gear-case increase in proportion." He also concludes that long swells "cause deflections fully as great as when the ship is operating in a storm." The largest deflections noted in the table, the rolling and pitching being heavy, were:—

Port for'd	Starboard for'd.	Port aft.	Starboard aft.
0·035 in.	0·022 in.	0·035 in.	0·021.

There can be no question that these strains were caused by similar ones buckling the ship, longitudinally or transversely, or warping it—strains to which every ship is necessarily liable. Mr. French's method did not indicate the type of strain; but it, no doubt, partook of both buckling and warping. In the paragraph I quote below he is seen to be definitely of the opinion that the casing was warped. As I indicated in my paper (vol. cxi, p. 641), this strain is the one which most seriously affects alignment and to which the gear-case offers least resistance. Also, the gear troubles which are being discussed prove the prominent presence of warping which, indeed, is inherently probable. It would be instructive to measure in the shop the forces necessary to give a large casing a sensible strain of this type.

The following is a very instructive paragraph:

"While this ship was *en route* from Baltimore to Glasgow in loaded condition, very heavy following seas were encountered, in some cases running as high as 20 ft., at which time deflections of 0·050 in. were recorded. When gears of this type are so mounted that deflections of the kind under consideration occur, the case is so warped that the pinions are thrown at an angle with the driving face of the gear; and at a time when the overload becomes 100 per cent., due to surges of the sea on the propeller, and with about 50 per cent. of the pinion face bearing on the gear face there is an overload on the driving face of the teeth of 400 per cent,* this occurring approximately every 8 seconds."

If I am correct in the belief I stated (vol. cxi, p. 610) that $\frac{1}{1000}$ in. is an important error of alignment of a bearing, even in a large gear, it will be realised how very far beyond allowable limits were the deflections noted by Mr. French. He is very conservative in his assumption that sometimes only half the tooth face was bearing. This is not the beneficient yielding of the gear casing "to ease off the effect of local stress" imagined by Sir Charles A. Parsons (vol. cxi, p. 348) but a very strong action due to the state of the sea.

It is not only by warping of the ship at sea that a rigid gear may be put out of line. The double check, in shop and ship, specified by the Admiralty, is proof of this. Slight heating of a bearing, unequal vertical or horizontal wear, the loosening or too tightly screwing up of a holding-down bolt, the grounding of the ship near the gear-casing, will all cause mis-alignment. All this I have pointed out in various papers, one of which was printed before the experimental gear was tried in

* Appendix to paper published in ENGINEERING, vol. cxi, page 609.

* With 100 per cent. overload and half the tooth face bearing the maximum tooth pressure would be about eight times that due to full load and uniform distribution of tooth pressure. See Fig. 1 of my paper.

1909. And these are all of a kind which cannot imaginably be obviated by any method of setting the gear, as the title of Mr. French's letter may be thought to suggest.

When one considers all this—Mr. French's measurements and other causes of bad tooth bearing—there can be little surprise at the widespread trouble which has supervened, not at the low tooth pressures experience has proved to be necessary for rigid gears, of which the authors give examples (vol. cxi, p. 369); nor that experience has produced a call for lowering of these low values (vol. cxi, p. 369).

The San Fernando affords an excellent illustration of the foregoing. The impulses from the four-bladed propeller set up severe synchronous torsional vibration, and consequently after the first trial it was noted that the "gearing had shown signs of distress at four different points around the gear wheel" (vol. cxi, p. 347). Sir Charles A. Parsons pointed out the cause of the trouble, and the pitch of the propeller was increased from 18 ft. 6 in. to 20 ft. 6 in., reducing the revolutions (vol. cxi, p. 369) so that synchronism was avoided. On the next voyage, instead of distress being shown at four points, the gearing was marked all round, and we are informed that this voyage was run in heavy weather (vol. cxi, p. 348). Sir Charles Parsons' explanation is that the shocks of the sea on the propeller blades now came at irregular intervals. But, there being now no synchronism, they would be very largely withstood by the inertia of the propeller and would reach the gear greatly mitigated. It seems to me incredible, considering the light tooth pressure of the San Fernando compared with that used in floating frame gears, that any detrimental marking would take place if unaccompanied by misalignment. Mr. French's observations leave little doubt that the true explanation lies in the warping of the ship due to the heavy weather of this voyage. Evidently the ship is sufficiently staunch and the tooth pressure small enough to keep within fair running condition in the average weather experienced, for we are assured that the teeth have polished up again. (vol. cxi, p. 369).

How admirably Mr. Hadley F. Brown's evidence, quoted in my paper (vol. cxi, p. 641), dovetails into the foregoing.

The authors' remark (vol. cxi, p. 369) that the expression "pressure per lineal inch of tooth surface" (or, more correctly, tooth face) has no real value unless the pinion diameter is given. But its value can only be judged when the pitch and all other data of the teeth are given; and it may be especially misleading unless the ratio of length of tooth face to pinion diameter is stated. To take an extreme illustration: If we have a pinion of 10 in. diameter and tooth face of 6 in. we may obviously impose a high pressure per inch, as the torsional and deflection errors are quite negligible and, with good alignment and tooth cutting, the distribution will be excellent. But, if the tooth face is made 120 in. long the deflection and torsional errors will be very large and the tooth pressure under other than an extremely light load will be highly localised. For the same factor of safety the load per inch will be very different in these two cases. Still keeping the same factor of safety, the power transmitted by this pinion at a given speed will increase as the tooth face is lengthened from 6 in.; will reach a maximum; and, on still greater increase, will diminish. From careful estimates I concluded that the maximum is reached for floating frame gears and pinions with three bearings at a tooth face of about four pinion diameters—in this case about 40 in. (vol. ci, p. 457). (For a rigid gear this best ratio will be less and for a two-bearing pinion very much less.) Hence a small change in this ratio, lengthening or shortening the tooth face from what gives the above maximum, while it will not sensibly change the safe power transmitted or the power constant, will very sensibly change the safe power transmitted or the power constant, will very sensibly change the safe tooth pressure per inch. Hence the power constant should be used in preference to tooth pressure; and, if the tooth face is short in any of the gears referred to by the authors, they were still more lightly loaded than is apparent from the constants given. I have discussed this question more fully in my Glasgow paper (T.I.E. and S. lxi, p. 345).*

* A good example of what I have stated is the Calderbank gear (vol. cxi, p. 369) which, apparently, the authors introduce to show that "considerably higher loads" (vol. cxi, p. 369) could be adopted than those at which some ship owners have baulked.

First, the Calderbank gear is a land gear, no doubt on a concrete foundation quite free from the warping which affects a ship's keelsons. Hence, even if it had been safe to judge from the pressure per inch and pressure constants given, 1,150 lb. and 298 lb. respectively, it would have had little bearing on the values allowable in a ship.

But only the pressure and diameter of the second reduction pinion are given, the speed, tooth face and number of pinion bearings, being omitted. The two latter are essential to a proper judgment.

Sir John Biles endorsed a plea made by Engineer-Captain W. Onyon (vol. cxi, p. 348) "for further information with regard to actual experience of high tooth pressures." Captain Onyon seems to doubt the authors' suggestion "that higher tooth loading was quite practicable." He asks—"Could the authors give him the names of any vessels with a tooth pressure constant [K of the empirical —D rule] of 220, which had run 20,000 miles at full power?" While not desiring to interfere with the authors' final reply I can say that many ships with floating frame gears have much more than fulfilled this condition.

I give in the subjoined table the data of 17 such ships:—

Ship.	K for Second Reduction Pinion.	Ratio = Tooth Face / Pinion Pitch Diameter.	Sailed. Distance.	Sailed. Date of Report.	Ship Delivered.	Remarks.
Agawam	320	3·90	66,750	June, 1921	Dec., 1918	August, 1919, gears replaced.
Auburn	260	3·90	79,700	June, 1921	Jan. 1919	Gears in good condition. No trouble.
Avondale	260	3·90	80,200	June, 1921	June, 1918	No trouble with second reduction.
Cabegon	320	3·90	62,060	Nov., 1920	Mar., 1919	No trouble with second reduction.
Coskata	320	3·90	78,000	Sept., 1920	Dec., 1919	Gears in good condition. No trouble.
Cushnet	320	3·90	70,000	Apr., 1921	Dec., 1919	Gears in good condition. No trouble.
Fort Pitt Bridge ..	320	3·90	60,000	Feb., 1921	May, 1919	Gears in good condition. No trouble.
Hisco	260	4·01	120,000	June, 1921	Dec., 1917	No trouble with second reduction.
Intan	320	3·90	80,000	Feb., 1921	June, 1919	Gears in good condition. No trouble.
Ipswich	260	4·01	61,000	May, 1921	June, 1919	September, 1919, second reduction renewed. Poor material. No further trouble with second reduction.
Jefferson County ..	320	3·90	60,000	Jan., 1921	July, 1919	Gears in good condition. No trouble.
Laural	292	3·33	56,000	Sept., 1920	Mar., 1919	Gears in good condition. No trouble.
Mystic	260	4·01	70,000	Feb., 1921	Apr., 1919	Gears in good condition. No trouble.
Overbrook	260	4·01	107,000	June, 1921	Apr., 1918	No trouble with second reduction.
Sudbury	296	3·09	109,000	May, 1921	May, 1918	No trouble with second reduction.
Toledo Bridge ..	320	3·90	65,000	May, 1921	Jan., 1920	Gears in good condition. No trouble.
Wathena	320	3·90	65,000	Feb., 1921	Jan., 1919	August, 1919, gears replaced. Gears in good condition. No trouble.

Complete data of the ships with floating-frame gears would greatly extend this table, the large proportion of such ships having sailed over 20,000 miles. The mileage in many cases would have been greater, but it was found when collecting the data of mileage for this paper that the shortage of freight had caused a considerable number of the ships to be laid up.† No doubt the sailing distance to date of some of the ships is considerably greater than given in the table.

The values of K in the table are for the second-reduction pinions at contract power and speed and do not include the 10 per cent. to 25 per cent. reserve power in the boilers and turbines. Hence, in some cases, the actual values used may have considerably exceeded those given.

Under "Remarks" it will be found that the gears of the Agawam and Wathena were replaced soon after the ships were delivered. These gears originally had the long addendum teeth in the pinion which, for reasons given in the body of my paper (vol. cxi, p. 640), are very liable to score. The new gears were of the same design as the original except that the long addendum tooth was displaced by one placing the arc of contact in its proper position.

The Westinghouse engineers inform me that only in the case of the Ipswich did any teeth break in the second reduction pinions. In this case the steel had evidently been burned. Usually there is slight pitting which appears early and soon stops, after which the teeth continue in good condition with no sensible wear. In the few cases where there has been sensible wear it was found that the hobbing had not been of the highest class. Where lubrication failed the teeth usually scored but always rebrightened after it was re-established.

In studying what the authors say regarding vibration, one is impressed by the fact that the large part of the difficulty arises from the rigid connection of the turbine to the gearing, and from the great energy of rotation of the turbine. The propeller shaft is the most flexible part of the mechanism and they quite wrongly state (vol. cxi, p. 370) "to provide this flexibility in any other way is almost impracticable." As stated in the last paragraph of my paper, the simple introduction of an elastic shaft between the turbine and pinion it actuates completely avoids the authors' difficulty. It is a great safeguard against serious vibration: so much so that no evidence of synchronous vibration in marine floating-frame gears has come to my knowledge.*

The gear is of 750 h.p. and the total ratio of reduction is

$$\frac{2{,}000}{70} = 28{\cdot}57 = 5{\cdot}35^2.$$

To keep the second-reduction gear small the second ratio might be kept as low as 4. It is improbable that it was over 5; but, if so, the pinion was still more lightly loaded.

Let l = length of tooth face in inches,
r = ratio of second reduction, and
C = the power constant.

Then 70 r = R.P.M. of the 14·9-in. pinion.
We have

$$\frac{1{,}150\ l \times 14{\cdot}9^2\ \pi \times 70\ r}{12} = 750 \times 33{,}000$$

or

$$l\,r = \frac{750 \times 33{,}000 \times 12}{1{,}150 \times 14{\cdot}9 \times 70\ \pi} = 78{\cdot}82$$

$$C = \frac{1{,}000 \times 750}{14{\cdot}9^3 \times 70\ r} = \frac{3{\cdot}239}{r}$$

If $r = 4$, $l = 19{\cdot}7$, and C = 0·810.
If $r = 5$, $l = 15{\cdot}8$, and C = 0·648.

Thus the tooth face is very short and this gear is under a very light load.

Reference to Fig. 2 of my paper will show that for C = 3·3, and $l = 4$ pinion diameters, the tooth pressure of a 14·9-in. pinion is 1,550 lb. per inch. With a power constant of 4, which has been quite successfully used, the tooth pressure rises to

$$\frac{1{,}550 \times 4}{3{\cdot}3} = 1{,}879.$$

The horse-power is

$$P = \frac{14{\cdot}9^3 \times 70\ r\,C}{1{,}000} = 231{\cdot}56\ r\,C.$$

According as we choose C = 3·3 or 4 and $r = 4$ or 5, we get values of P from 3,057 to 4,631: that is, from four to six times the power of the Calderbank gear with the same diameter and speed of pinion.

† The statement in the body of my paper that "many of the ships have sailed between one and two hundred thousand miles" (vol. cxi, p. 641) was founded on data furnished me in which the distances sailed had been in part estimated, not knowing of those laid up. I regret this exaggeration. It is found now that only nine ships are certainly known to have exceeded 100,000 miles.

* Only in the case of one geared turbine driving a generator on land, so far as I know, did the normal speed nearly coincide with a critical speed and produced considerable vibration. The alteration needed to change the critical speed was obvious.

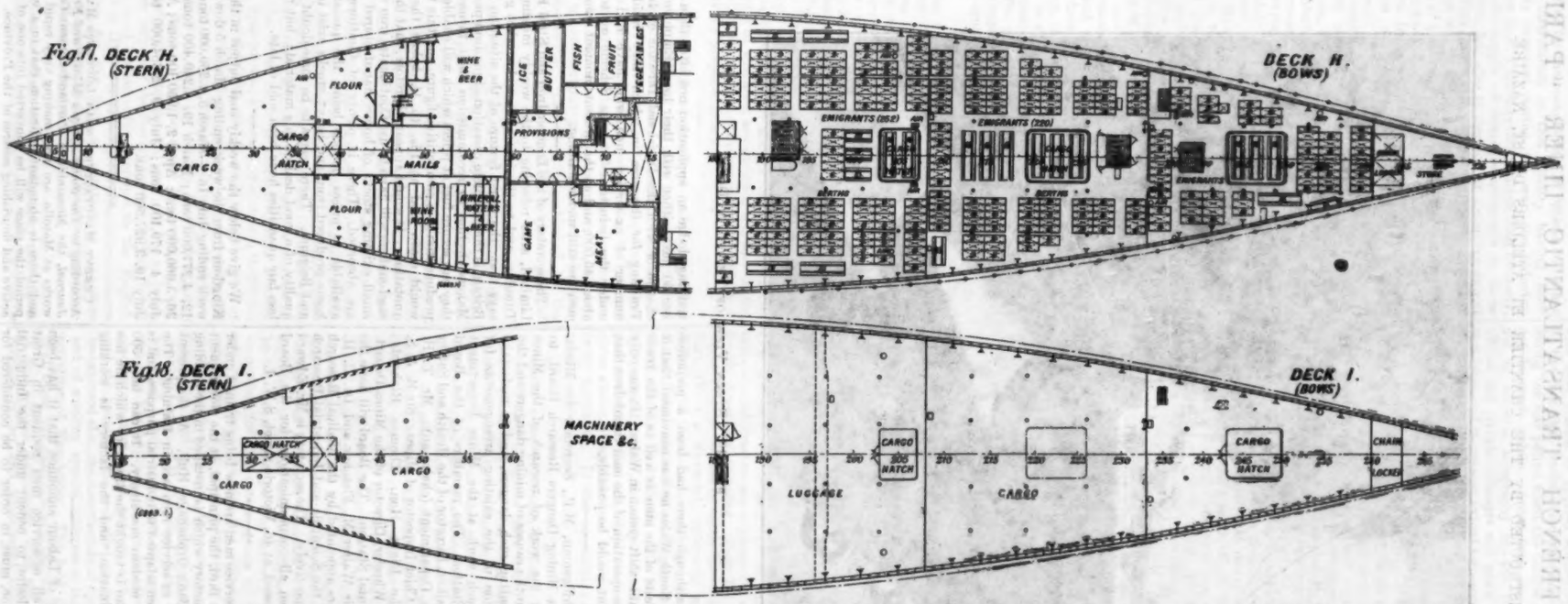
"SAFETY FIRST" SIGNS.—The Pyrene Company, Limited, 9, Grosvenor Gardens, S.W. 1, has issued a series of "Safety First" signs for affixing wherever there is a risky and a safe way of working, and particularly where safety devices have been provided for the use of employees. Other series are "Warning" signs and "Danger" signs.

CONTRACTION OF SAL TIMBER WHILE SEASONING.—Mr. R. S. Pearson, forest economist, has carried out tests on the contraction of sal timber while seasoning, says *Indian Engineering*. The specimen plank under test was 12 in. by 12 in. by 1 in., and records were made of contraction and expansion across the grain. The tree from which the plank was taken was felled on May 17, 1919, and cut from the log two days later, and contained 39·87 per cent. of moisture. The experiments started on May 20, 1919, and daily readings were taken till June 12, 1920. Results show that the plank contracted 0·455 of an inch over a 12-in. surface. The rate of contraction was fairly uniform, except during the monsoon when the humidity had the effect of retarding the seasoning to some extent. By June, 1920, the timber was thoroughly seasoned and contained 7·5 per cent. of moisture.

ZINC IN CANADA.—According to *Canadian Machinery*, a recent report issued by the Imperial Mineral Resources Bureau shows that the output of zinc from Canadian mines has more than quadrupled since 1916. Previous to that year the output was negligible and the bureau did not keep a record of it. According to figures given in the report, the output from Canadian mines in 1916 was 2,655 tons. In 1919 production had jumped to 11,005 tons. Reporting on the deposits within the Empire the report attached special significance to the zinc-lead-silver ores in British Columbia and to the development of proper handling facilities at Trail, B.C. Much still remains to be done before the British Empire can be considered self-supporting in the matter of spelter production, the report stated. In this connection the construction of a successful electrolytic-treatment plant at Trail, with a capacity of 15,000 tons of spelter a year, was given as a hopeful indication.

THE TURBINE DRIVEN QUADRUPLE-SCREW TRANSATLANTIC LINER "PARIS."

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHANTIER ET ATELIERS DE ST. NAZAIRE.



THE FRENCH TRANSATLANTIC LINER "PARIS."

(*Continued from page* 97.)

THE deck D, as stated in our former article, is the first entire deck from stem to stern, and is illustrated in the plan, Fig. 12, on Plate VIII; this deck is mainly set apart for the accommodation of first-class passengers. The upper portion of the first-class dining room is forward of the main stairway on the port and starboard sides of the ship. The children's dining room is close to the main stairway. Forward of the first-class dining room are a number of first-class cabins, with a still larger proportion aft of the main stairway. Further aft are a few second-class cabins, whilst the deck right aft is set apart as a promenade for the *personnel* of the ship. The covered promenade for third-class passengers and emigrants referred to in our former article is shown in Fig. 12, in the fore part of the vessel.

The deck E, Fig. 13, on Plate VIII, has a few first-class cabins, the first and second-class galleys and the two main dining rooms. The first-class dining room has a length of 20 m. (65 ft. 7 in.) and is 26 m. (85 ft. 3 in.) in breadth; it has two floors and is lighted by a dome. As many as 550 passengers can be seated at a time round the small tables with which the first-class dining room is provided, The extent of the accommodation enables all passengers to dine at one service. The decorations are by Messrs. Rémon; at one end is a painting by Besnard, the subject of which is allegorical of the French metropolis, whilst at the other is the artistic stairway in ironwork shown in the view, Fig. 7, on page 96 *ante*, establishing communication between the two floors of the dining room. The sides of the dining room are decorated in inlaid wood and gilt work. The vaulting at the central part is supported by black marble pilasters gilded and having ironwork settings. The balcony and internal balustrade are of decorative ironwork. The ceiling is of glass combined with decorative wire-netting. Directly aft of the first-class dining room are the issue or service rooms, pantries and all necessary rooms for the glassware, silver plate and cutlery, also the butler's pantry, &c. The central part of the main issue room is set apart for receiving and distributing the dishes; this service room (see Fig. 13) is horseshoe shaped and is connected with four service rooms above (see Fig. 12) by two stairways and two lifts. It is separated from the first and second-class galley by a partition in which there have been formed openings to give access to hot food safes.

The galley, which is aft of these offices, is 17 m. (55 ft. 9 in.) by 26 m. (85 ft. 3 in.). The central cooking range which it contains is accessible on all sides, and the smoke is drawn off from underneath. Above the range is a hood for evacuating the hot air through a casing which surrounds the third funnel of the ship. The hood is decorated with ceramic tiling. Besides this range, the galley is provided with Cubain-Mildé electric grills and roasting stoves, the latter being capable of dealing at a time with 18 fowls. Around the galley are separate compartments for dealing with all vegetable food, equipped with steam-heated cooking appliances and for all fish dishes. The second-class main service room (Fig. 13) is directly forward of the second-class dining room. The decoration of this dining room has also been carried out with great care, and consists of wood inlaid work, wood pilasters and carvings on the lighter groundwork of the sides and ceiling. The first and second-class galley is in direct communication by electric lifts and stairways with the food storage compartments and cold store rooms; the latter are located directly above the refrigerating plant. It will thus be seen that in the construction of the Paris the general arrangement followed in all modern liners has been adopted, an arrangement which consists in grouping all the food providing services, i.e., the main galley and all its attendant rooms and compartments, between the first and second-class dining rooms, and above the food stores and cold stores, all the various compartments being in direct communication one with the other. The forward part of the deck E is divided into first-class cabins, and forward of these, in separate rooms, are the sick berths for male and female passengers. A special hold for first-class passengers' luggage is available, in which these passengers can have access to their luggage during the voyage. Accommodation for third-class passengers is provided right forward of the deck E, whilst aft of the same deck are second-class cabins.

The greater portion of the deck F (Fig. 14) has been set apart for third-class passengers. The dining room and galley for this class are in the central part of the ship, with the smoking room on the port side near by. The third-class galley is located directly underneath the one for first and second-class passengers, and the hot air is also evacuated through the casing round the aft funnel. All the third-class passengers are accommodated in cabins. A number of second-class cabins are aft on this same deck.

The deck G (Fig. 15) is above the water-line and contains aft the accommodation for the *personnel* of the ship and the engine-room complement. In

the central part are the workshop, the engine-room stores, coal bunkers for the galleys and a number of third-class cabins, whilst right forward are emigrants' quarters.

The deck H is shown in Fig. 17, on page 181. The aft portion is divided into compartments and refrigerating rooms accommodating the food stores, the forward portion forming a part of the emigrants' quarters. The deck I, Fig. 18, on the same page, fore and aft of the ship, constitutes two floors in the hold for the storage of goods and cargo.

The engine space is illustrated in the plan, Fig. 16, on Plate VIII. There are five stokeholds in the central portion of the ship, each containing three double-ended boilers in the centre, and oil fuel tanks at the sides. The engine-room aft of the stokehold contains the low-pressure turbines in the centre and the high and intermediate-pressure turbines in the wings, the general arrangement of the machinery being shown in Fig. 16.

The stern of the ship in dry dock is illustrated in the view, Fig. 19, annexed. Further illustrations and a description of the machinery will be given in a subsequent issue.

(To be continued.)

INDUSTRIAL NOTES.

SPEAKING last Saturday at Bessemer House, Denmark Hill, to a gathering of Coalition Liberals Dr. Macnamara stated that employers and employed were now conferring frankly together throughout the country and making agreements which avoided stoppage of work. As Minister of Labour, he felt greatly pleased at the spirit of mutual self-respect with which difficulties were negotiated and brought in many districts to a successful conclusion. What the country now wanted was the determination not only that the revival in trade shall not be hampered by further strife, but that it shall be taken advantage of to the fullest extent possible.

Negotiations in regard to a reduction in wages were resumed at a conference held in London last Monday, between the Federation of Master Printers and the Newspaper Society and the Printing and Kindred Trades Federation. It was stated that the Lithographic Printers' Union, the Typographical Association, the London Society of Compositors, and the Electrotypers and Stereotypers' Union were not represented. An agreement was reached on the point of recommending that a reduction of 5*s.* per week from the wages paid to all adult male members of unions affiliated to the Printing and Kindred Trades Federation for whom the Federation were empowered to negotiate, shall take effect on the pay-day in the week ending August 13, and a further 5*s.* per week reduction on the pay-day in the week ending September 10. For all fully-qualified women workers it was decided that a reduction of 2*s.* per week be made on the pay-day in the week ending August 13, with a further reduction of 1*s.* 6*d.* per week on the pay-day in the week ending September 10; also a corresponding adjustment of the wages scale to the male learners and junior women workers, and also piece workers.

The Joint Industrial Council of the Printing and Allied Trades met in London on Tuesday and discussed the position which exists between the Employers' Federation and the Typographical Association, London Society of Compositors, Stereotypers and Electrotypers Society, and the Amalgamated Society of Lithographic Printers. A resolution was passed unanimously recommending the parties to resume negotiations, and it was provisionally agreed that these meetings should take place on Wednesday next, August 3.

The forty-eighth annual general meeting of the Tredegar Iron and Coal Company, Limited, was held last week, and Lord Aberconway, the chairman, after referring to the coal settlement said there was now a material inducement to increased effort on the part of the men, and he was glad to add that the output per man per day at the face since the pits restarted showed a very marked improvement as compared with the output per man per day before the strike. At the Whitworth Colliery the company had found themselves compelled to stop permanently, and they also proposed to stop temporarily part of the Bedwellty No. 2 pit. There were certain districts of other collieries where working costs were abnormally high, and those they did not see their way to reopen until coal prices and costs were more definitely ascertained. The fact that they could not open some of these districts showed the importance of introducing new systems of working into South Wales. Double shifts had been a great success in the Midlands, and although there had been a prejudice against them in South Wales he was convinced that it was in the interests of the men as well as of the trade to adopt the double shift system in Wales. It was only by the cordial co-operation of the men themselves that this improvement would be possible.

Mr. W. C. Bridgeman, M.P., Secretary for Mines, has appointed a Mining Dangers Research Board, to direct generally the work of research of the Mines Department into the causes of mining dangers and the means for preventing such dangers, and to undertake the reorganisation of the existing arrangements for carrying out such work at the Mines Department Experimental Station. The members of the Board are: Mr. W. Walker, Director of the Health and Safety Division, Mines Department (chairman); Mr. T. H. Mottram, H.M. Chief Inspector of Mines; Sir R. A. S. Redmayne; the Right Hon. Thomas Richards; Professor R. V. Wheeler, Director of the Mines Department Experimental Station. The Board will have the assistance of Sir Walter M. Fletcher and Dr. C. H. Lander, assessors appointed by the Medical Research Committee and the Scientific and Industrial Research Department respectively. The secretary is Mr. Edward Fudge, to whom all communications for the Board should be addressed, at 46, Victoria street, S.W. 1.

Disabled ex-service men are now being trained under Captain Walter Bird, the principal, at the Government Instructional Factory which is installed in the building of the Spring Bank Orphanage, Hull. At the present time over 200 ex-service men are in training. The building has been adapted to industrial purposes and is equipped with modern machinery. It can take 500 men. Each man is taught the trade for which he has a special inclination, and the factory is working admirably.

The Ministry of Labour announce that it has been decided that all ex-service men resident in Great Britain who desire to benefit under the Industrial Training Scheme, must, in order to be considered for training, lodge an application not later than September 30 next, either with their local Employment Exchange or with the Divisional Director of Industrial Training for the area in which they reside. The number of ex-service men who have had training under the Industrial Training Scheme up to date is about 45,000, and at the present moment some 24,000 men are still under training.

The secretary of the London Iron and Steel Exchange Limited, after referring to the weekly meeting of last Tuesday, and to the iron and steel market generally, says that the worst feature of the situation in Great Britain is the complete cessation of pig-iron production. Makers decline to recommission their furnaces until they can secure fuel at prices which will enable them to produce iron at a competitive figure, and this they said would mean coal at 15*s.* to 1*l.* below the current quotation. It would appear, therefore, that the British steel-makers will have to use Continental iron when the small existing stocks of home manufactured material are absorbed. There is plenty of Continental iron available at prices pounds below the quotations for home produced iron, and heavy stocks exist in France and Belgium. There seems to be some doubt as to the quality of a good deal of this material; but nevertheless fair quantities have been sold of late.

We give below the weekly coal output in the United Kingdom from the week ending March 5 down to the week ending July 16:—March 5, 4,259,000 tons; March 12, 4,277,000 tons; March 19, 4,240,400 tons; March 26, 3,660,000 tons; April 2, 1,950,100 tons; April 4 to July 4, 179,100 tons; July 9, 2,354,000 tons, and July 16, 3,927,500 tons.

CEMENT MANUFACTURE NEAR LOURENÇO-MARQUES.—According to *The South African Mining and Engineering Journal*, the Mozambique Portland Cement Company's works at Matolla are now making very rapid progress, and there is abundant indication that in a very short period the place will be converted into one of the most active and flourishing centres of the Province.

THE FRENCH TRANSATLANTIC LINER "PARIS."

CONSTRUCTED BY THE CHANTIER ET ATELIERS DE ST. NAZAIRE.

FIG. 19. STERN VIEW OF VESSEL IN DOCK.

NOTES ON NEW BOOKS.

FACILITIES for the manufacture of optical and other scientific instruments in this country having been enormously increased during the war, the industry should now be in a much better position than formerly, not only to supply all home requirements in these commodities, but also to develop an extensive export trade. With this object in view the British Optical Instrument Manufacturers' Association, which includes nearly 30 of the largest firms in the country, has been formed, and one direction in which the activities of this body have been applied is in the compilation and publication of a "*Dictionary of British Scientific Instruments*." The dictionary, which we should estimate contains some 3,000 entries, gives a concise description of each instrument, and also indicates, in each case, the names of the firms in the Association who manufacture it. The entries range from the abacus to the zymoismeter, the latter instrument, we should perhaps explain, being used for ascertaining the degree of fermentation occasioned by the mixture of different liquids and the temperature acquired during the process. Many uncommon instruments are, of course, included in the list, as well as those with which all engineers are familiar, and although the work is intended mainly for reference rather than for perusal, there are few persons, we imagine, who would not gain some information by studying its contents. The dictionary is followed by about 150 pages of illustrations of instruments, obviously reprinted from the makers' catalogues, and arranged with sub-titles in alphabetical order. The separation of these illustrations from the descriptions, although rather inconvenient, is, we suppose, unavoidable, but it would certainly be an improvement to include in the descriptions references to the pages on which the illustrations occur. The price of the book, which is published by Messrs. Constable and Co., Ltd., 10, Orange-street, Leicester-square, London, W.C., is one guinea.

Business men and tourists who are interested in South and East Africa, and who require detailed particulars on that part of the African Continent, could not do better than read the information and follow the recommendations contained in "*The South and East African Year Book and Guide*," which is edited by Messrs. A. S. Brown and G. G. Brown, and is published at the price of 5*s.* net, post free 5*s.* 9*d.*, by Messrs. Sampson, Low, Marston and Co., Limited, London. The edition for the current year is the 27th annual edition. In this volume, the very clear series of maps which have always formed a characteristic feature of the book are grouped together at the end. Reference to the contents is facilitated by a very carefully prepared index.

Information of great practical value respecting non-ferrous metallurgy and the behaviour of non-ferrous metals under very numerous conditions is contained in Vol. xxv. of the "*Journal of the Institute of Metals*," which gives the papers read at the last spring meeting in London and the discussions thereon, followed by abstracts of papers of every country, relating to non-ferrous metals and industries connected therewith. The book is published by the Institute, 36, Victoria-street, S.W. 1, at the price of 31*s.* 6*d.* net.

At the present time when it is more necessary than it has ever been for us to extend our trade generally, a guide to export and import, shipping and manufacturing industries forms a most important and welcome help. Such a guide is "*Kelly's Directory of Merchants, Manufacturers and Shippers of the World*, 1921," published in two volumes by Kelly's Directories, Limited, whose new London address is 186, Strand, W.C. 2. The price of the two volumes is 64*s.* net. Volume I covers Europe, Asia and America. It opens with an index to countries and towns arranged alphabetically, followed by an alphabetical index in English of trades, this index giving further the towns in which the various trades are carried out and references to pages. The trade index is translated into French, German, Spanish and Russian. Reference, therefore, to each separate town and to each separate trade or industry is rendered most easy, and the directory can be used by a large number of foreign countries. Volume II is set apart for London, the United Kingdom and British Dominions and Dependencies, and is arranged in the same general way; it has an index in English only, but the foreign indexes in Vol. I will apply in most instances for reference to the English index of Vol. II. Vol. II also gives consulate addresses regulations for the help of commercial travellers abroad and other useful data to facilitate business intercourse with the whole world.

The extent to which wireless telegraphy now affects our national life and international relationships is perhaps hardly realised by those not directly connected with that branch of applied science—possibly owing to the fact that enormous developments were made during the war period when the results achieved could not be made public. Apart from the more obvious use of wireless telegraphy in the transmission of official and private messages and news, it is employed to a large and increasing extent for supplying meteorological data, and time signals, as well as in connection with navigation and aviation. All these, and other, applications are dealt with in the current issue of the "*Year Book of Wireless Telegraphy and Telephony*," which is published by the Wireless Press, Limited, 12–13, Henrietta-street, Strand, W.C. 2, at the price of 21*s.* net, and even a casual examination of this publication would suffice to indicate the important position the science has now attained. The greater part of the Year Book is occupied by reprints of the laws and regulations relating to wireless telegraph for all countries of the world, by lists of all existing ship and land stations, and by an alphabetical list of call letters. In connection with the list of land stations it is interesting to notice that the exact geographical position of each station is given, so that ships fitted with direction-finding apparatus can use these data for the accurate determination of their positions. Numerous short articles describing the technical progress in various countries of the world during 1920 are included, together with a number of special articles on wireless subjects, such as the radio-compass valve amplifiers for use on ships, interference in reception, and the history of wireless inventions. These, together with the mass of useful information and data included, make the work practically indispensable to operators and others interested in wireless either as professionals or amateurs.

Geographical data, particulars as to the climate, the history, political constitution, finance, trade, Army and Navy, products and industries, commercial demands and opportunities of each South and Central American Republic are contained in the "*Anglo-South American Handbook for* 1921" (incorporating Mexico and Central America), edited by Mr. W. H. Koebel, and issued by the Federation of British Industries, 39, St. James'-street, S.W. 1, and by Messrs. T. Fisher Unwin, Limited, Adelphi-terrace, W.C. 2, at the price of 25*s.* net. The information we refer to covers all the first part of the book. The second part deals with the Board of Trade, the Department of Overseas Trade, the London Chamber of Commerce, and with the facilities these bodies offer to exporters to South and Central America. It contains also information as to passports and Central and South American shipping. Part III applies to the River Plate estancias or cattle-breeding associations; Part IV is a financial, industrial and commercial directory of the various republics; and Part V. states the activities of the British Engineers' Association in South America in 1919–20. The book contains over 900 pages of matter, indexed in detail, and as will be gathered from the very brief indications we have given above, it appeals to a wide circle of traders in every speciality. It also constitutes a valuable desk reference book.

Whilst other important although secondary cities in the United Kingdom have issued for many years past a guide book or a year book setting forth their actual trade and the facilities they offer for still further trade, not to speak of other advantages, it seems somewhat abnormal that Manchester should hitherto have lacked a publication of this nature. The appearance of "*The Manchester Guardian Commercial Year Book*, 1921," is therefore welcome. It measures 7¼ in. by 5 in., and contains close upon 300 pages of subject-matter reviewing all the various industries of the city. The name of Manchester has always been associated with cotton, and that commodity forms the subject of conversation in every hotel in the city, as any visitor bent on other trades will readily ascertain, but "Manchester itself no longer produces cotton goods to any considerable extent, and its mills have been replaced by warehouses and packing-houses; as a market or emporium for the cotton goods of Lancashire and adjoining areas the city has achieved a world-wide reputation." The other industries of Manchester are most important also; the construction of textile machinery, and very naturally so, has always been a striking feature of the business of the City and neighbourhood. Quite apart from this speciality, however, the city has acquired renown in other branches, including machine tools, engines and motors, boilers, and the heaviest iron and steel products. As was to be expected also, the manufacture of dyes and chemicals and of wearing apparel occupies a large place in the activities of Manchester. The book gives particulars of all these, and deals also with the facilities of transport in and around Manchester, with the financial, commercial, labour and educational organisations. The book contains maps and illustrations; we hope it will have a wide circulation. It can be obtained from the Editor of the "*Manchester Guardian Commercial Year Book*," Guardian Building, Manchester.

Mineral oil is fast becoming an essential auxiliary to everyday life, and every information, including statistics, concerning it is sure to be attractive. Such information is contained in "*The Petroleum Year Book*," for the current year, a book which was founded and is edited by Mr. S. H. North, and is published by the St. James' Press, Limited, 15, Henrietta-street, W.C. 2. [Price 10*s.* 6*d.* net.] It reviews the petroleum fields throughout the world, gives their characteristic features, their production over a number of years, and many other data both on the natural and manufactured product including analyses, regulations for carrying or burning oil fuel, specifications, &c. A special chapter deals with various marine Diesel engines, and the book defines also a number of petroleum terms. The book is carefully indexed, and forms a handy source of reference on a most important commodity.

Most writers on elementary chemistry try to explain atomic weights before they pass to multiple proportions. In his "*Factory Chemistry Preparatory to Courses in Metallurgy and Metallography*." [Longmans, Green & Co., 4*s.* 6*d.* net], Mr. W. H. Hawkes, A.B.M.Sc., begins with Valence and proceeds to General Definitions and Chemical Terms, Chemical Laws, more Chemical Terms, Composition, Properties and Construction (a strange expression) of Acids, Bases and Salts and Qualitative Analysis, &c., without ever mentioning atomic weights, except in the table of the 42 more common elements to which he confines himself. Perhaps he has simply forgotten to speak of atomic weights, though he especially mentions them in his preface. The absence of system, shown by his classification, makes one suspect that he dictated the volume at odd moments. Mr. Hawkes (of the Department of Chemistry, Ford Institute of Chemistry, Detroit), is evidently fond of valency. He devotes 5 pages—out of a total of 59—to diagrams illustrating valency relations. Yet he describes carbon manganese and silicon as divalent or tetravalent, which is somewhat surprising, and he does not seem to know any heptavalent elements. He writes for factory men and appears to think particularly of attendants in metallurgical laboratories. We are rather doubtful about the benefit they will derive from the study of his "Factory Chemistry," though we do not wish to imply that the book has no good points. If it is supplementary to some other volume, he should have said so.

THE LUMSDEN SYSTEM FOR LATHE-TYPE TOOLS.

IT is somewhat astonishing that the lavish care bestowed on the standardisation and upkeep of such tools as milling cutters, twist drills, reamers and broaches, is seldom extended to cover cutting tools of the lathe type. The first quoted classes are, of course, comparatively expensive tools, some of them being very costly indeed, and this possibly accounts for the attention devoted to them. They are scrupulously designed and manufactured, finished to perfection by grinding in the tool room, are drawn from there for use, and returned when done with. Every check is made to prevent abuse, either by over use or by allowing them to be sharpened or repaired by any but the most skilled labour whose special duty is the maintenance of these high-class tools in first-rate order. Contrast this with the usual practice with regard to tools for the lathe, slotter, shaper or planer. Ordinarily speaking any one running one of these machines is considered to be conversant with suitable tool shapes, and to be capable of giving his tools a satisfactory edge and angles for any class of work he may be on. Although we have in some cases advanced a little on the old days when every machinist got the smith to make his tools just as he thought best, even now when repetition tool grinders have been available for years, and a mass of reliable knowledge on cutting tools has accumulated, the idea of a regularised tool system has made comparatively little headway. It was taken up in the United States on a comprehensive scale in works rather earlier than in this country, and was found under many circumstances to be more than justified. It now also forms an integral part of shop methods in works in this country, but not nearly to the extent possible.

Naturally the scope of such a system varies with the class of the shop. It is possible to imagine works engaged in purely repetition manufacturing in which every lathe tool might be a standard or a formed cutter. Such a shop is not likely to exist often in practice. At the other extreme would be a jobbing shop engaged on a very wide range of work for which nearly every job might require special tools. Again, such a shop is not likely to be encountered in practice. Actually it is found in the average general shop,

THE LUMSDEN SYSTEM FOR LATHE-TYPE TOOLS.

FIG. 1. TOOL-ROOM FOR LATHE-TYPE TOOLS.

FIG. 2. GRINDING MACHINES IN TOOL-ROOM.

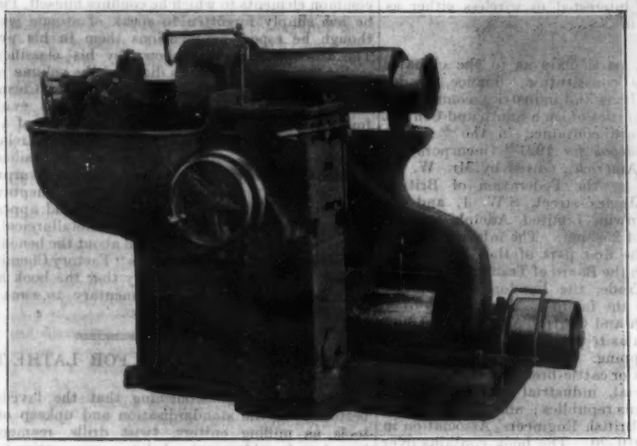


FIG. 3. NEAR SIDE OF OSCILLATING GRINDER.

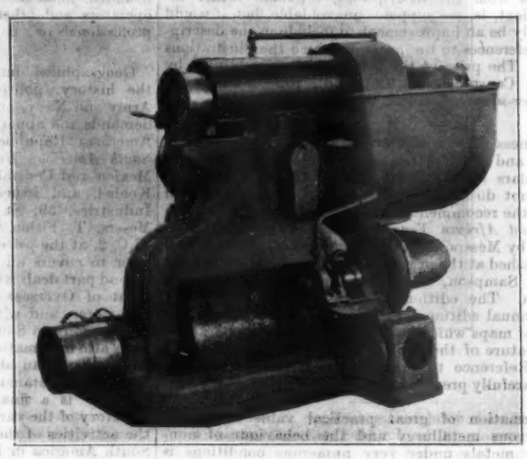


FIG. 4. OFF SIDE OF OSCILLATING GRINDER.

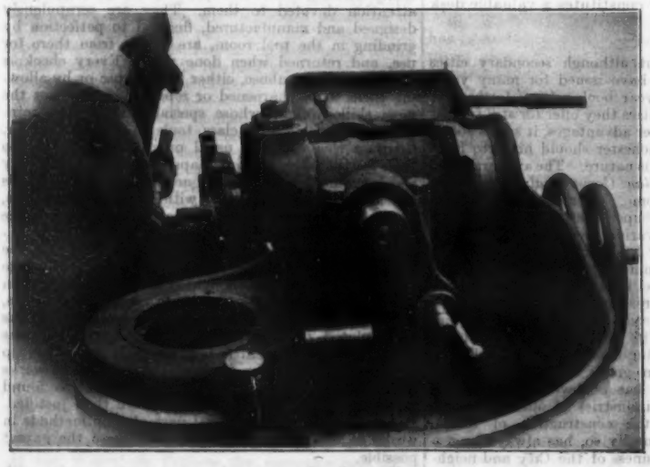


FIG. 5. TOOL-HOLDER SHOWING TURNTABLE.

FIG. 6. TOOL-HOLDER SHOWING CLAMPS FOR TURNTABLE AND TRUNNIONS.

equipped with a selection of machines including lathes, boring mills, slotters, shapers, planers, &c., that considerably more than half the machines can be embraced within a systematised range of tools. The difficulties of deciding upon this range, in practice, will be found to be rather apparent than real—the real work begins when, having got a suitable system, the time comes to apply it in the shops.

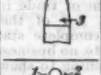
The amount of information available on shapes and cutting angles is now very considerable. It is impossible for all machinists, even if they know the facts, to be equally sound in applying them to their work. As often as not in the application the average man will mechanically introduce some little fad of his own, thereby falling short of the efficiency to be aimed at. In theory it must be admitted that where the men are of varying intelligence, as they always are, and where there is even a sprinkling of older hands whose tendency

is to be conservative in these matters, the work is improved if a really well-trained expert can take charge and demonstrate the relative utility of different tools and the satisfactory operation of the standards adopted. A good deal more than a cut-and-dried scheme of shapes and angles is required. Tact, firmness and practical resource are necessary to get the system working smoothly.

In working out the system it may be found advisable to supply each man with a full set of tools suitable for the range of work on his machine. This is not always necessary, however, and smaller sets of the tools in most common use may be supplied, the others, less often wanted, being drawn from the toolroom when required. The latter method is found to reduce considerably the amount of steel in use. It is quite possible with this system to make up different sets for men at similar machines, but employed more or less regularly on different classes of work. Either system requires an ample supply of reserves in the toolroom to replace without the least delay blunted or damaged tools as soon as presented at the window. A check system or some system of booking out will usually be found necessary for tools not in the regular sets and drawn only as required. In practice such a system almost necessitates the removal of all accessible grinding machines and stones, and their concentration in the toolroom, in order to remove the temptation for individual men to introduce slight changes on their own account. If a man is convinced that something of the kind is necessary the system of control should be flexible enough for the tool chargeman to use a certain amount of discretion in dealing with the case.

Properly run, such a system saves the men a great deal of time and trouble, and is generally appreciated.

TABLE I.—TYPICAL SET OF LATHE-TYPE TOOLS.

Name.	No.	Tool.	Operation.	Settings in Degrees for Profile and Flat Top Faces. Turn-table.	Trunnion.	Tool-holder
				deg.	deg.	deg.
Shaping.	1*		1	10	6	3
			2	10	6	3
			3	15	0	0
Round Nose Roughing. Right.	2*		1	10	6	3
			2	10	6	3
			3	10	0	15
Round Nose Roughing. Left.	3*		1	10	6	3
			2	10	6	3
			3	10	0	15
Straight Roughing. Right.	4		1	35	6	6
			2	50	6	0
			3	15	0	22
Straight Roughing. Left.	5		1	35	6	6
			2	50	6	0
			3	15	0	22
Bent Roughing. Right.	6		1	45	6	6
			2	45	6	0
			3	18	0	18
Bent Roughing. Left.	7		1	45	6	6
			2	45	6	0
			3	18	0	18
Finishing. Right.	8		1	90	6	0
			2	0	0	6
			3	25	0	0
			4	15	0	0
Narrow. Left.	9		1	90	6	0
			2	0	0	6
			3	25	0	0
			4	15	0	0
Broad Finishing.	10		1	90	6	0
			2	0	0	6
			3	0	0	6
			4	15	0	0
Recessing.	11		1	90	6	0
			2	3	0	3
			3	3	0	3
			4	15	0	0
Double Side.	12		1	0	0	6
			2	0	0	6
			3	90	6	0
L-Shaped. Recessing.	13	Use Adapter	1	87	6	0
			2	0	0	10
			3	0	0	10
			4	3	6	6
L-Shaped. Roughing.	14		1	80	6	0
			2	10	0	10
			3	10	0	10
Trailing Roughing. Right.	15		1	5	6	3
			2	75	6	0
			3	2	0	20
Trailing Roughing. Left.	16		1	5	6	3
			2	75	6	0
			3	2	0	20
Bar Turning.	17		1	45	6	6
			2	45	6	0
			3	18	0	18
Parting.	18		1	45	6	6
			2	45	6	0
			3	18	0	18
Screw Cutting.	19		1	90	6	0
			2	0	0	7
			3	0	0	35
Brass Cutting.	20		1	90	6	0
			2	1	0	2
			3	1	0	2
			4	0	0	0
Slotting.	21		1	0	0	0
			2	27½	6	10
			3	27½	6	0
			4	15	0	0
Single Radius.	22		1	90	6	6
			2	30	6	6
			3	30	6	6
			4	0	0	0
Double Radius.	23		1	80	0	0
			2	3	0	3
			3	3	0	3
			4	10	0	0
	24		1	90	6	6
			2	0	6	6
			3	Set for required radius and work turntable to suit.		
	25		1	90	6	6
			2	0	6	6
			3	0	6	6
			4	Set for required radius and work turntable between zero and 90 in conjunction with settings 1 and 2.		
			5	In conjunction with 1 and 3.		

* Set tool in holder to give radius on sides equal to width of tool, *e.g.*, 1 in. by 1½ in. section set for operation 1 radius offset to right, 1 in.; sweep off radius after operations 1 and 2.

(4813)

No one to-day would dream of a twist drill being ground except on the proper machine in the toolroom, and afterwards being placed to stock ready to meet a subsequent call. The same method will undoubtedly answer with a large range of the lathe type tools. In Fig. 1, page 184, we illustrate the store of a shop in the North of England, where this system has been in use for several years. The racks, which are admittedly capable of improvement, contain sharpened tools of standard shapes. These tools are handed out to the machine operators over a counter in exchange for returned ones. Some way down the store may be seen racks for the standard sections of tool steel, and beyond are the grinding machines shown again in Fig. 2, where the tools are put through in batches, so that economy is realised in settings and manipulation, and exact repetition of shapes is ensured. The grinding machine and other equipment of such a toolroom will depend naturally on the size of shop to be served and the range of tools required. For instance, one oscillating Lumsden grinder will keep a machine shop of 150 to 300 hands supplied, with a plain cup grinder for touching up after hardening and re-sharpening, &c. If the range of tools includes patterns with curved top rake, either an attachment may be used with the oscillating grinder, or, for larger shops, the more recent curved rake tool grinder also by the Lumsden Machine Company. Other equipment may include the gauge and form grinder by the same firm, for reproducing special form tools.

The sections of tool steel required vary with the range of machines as regards type and size, and the standard shapes must be easily reproducible. In Table I we give a typical modern series of standards, all of which can be readily produced on the Lumsden oscillating tool grinder. The figures given in the columns are angles or approximate angles to which the tools are ground. These shapes and angles may be varied according to circumstances, but the selection given covers a large range of work. It should be pointed out that the use of the term "approximate angles" does not imply inaccuracy of setting. The term is employed because the actual angle of the cutting edge is frequently a combination of two machine settings, one to give a front cutting angle, and one to give a side-cutting angle. The real cutting angle or that given by a line drawn normal to the actual cutting edge, is a combination of these two.

It may be of interest to give a brief description of this machine with the settings required for some of the tools given in Table I. We illustrate, therefore, the Lumsden oscillating grinder in Figs. 3 to 6 opposite. In this machine a cup wheel is mounted on a large oscillating frame which can be clearly seen in our views, of which Fig. 3 presents the operating side and Fig. 4 the back of the machine. The driving pulley and drum countershaft in the base are mounted in ball bearings, and the wheel spindle is similarly mounted in the oscillating frame. The oscillating frame receives its movement from a variable eccentric gear in a gear-box, coupled to the frame by a connecting rod and swivel joint. The gear-box is also fitted with ball-bearings. The controls are centralised and consist in the main of two handwheels and one lever and a pedal seen in Fig. 3. Of the hand-wheels the outer one is for the wheel feed, *i.e.*, moving the wheel and spindle, by gears engaging with the rack visible in Fig. 5, the grinding taking place on the flat face of the cup. The inner handwheel is used for swinging the wheel into position sideways. The lever operates the gear-box and thus controls the amount of oscillation of the wheel and frame, while the pedal operates the belt shifter for starting and stopping the machine. The machine is fitted with water supply by pump, and with a dust exhausting fan for dry grinding, which latter method is preferred for tool grinding. The universal tool holder is shown to a larger scale in Fig. 5 and Fig. 6. It has numerous adjustments. The holder proper is contained in a sleeve mounted on trunnions and is fitted internally with Vee-grips to take the rectangular tools. The holder can revolve on its own axis, and can be tilted on the trunnions of the sleeve, which is carried in two brackets of a turntable. The whole arrangement can swivel round the vertical axis of the turntable, while the holder and sleeve can also be traversed on the trunnion bearings, by means of the screw shown in Fig. 6, between the two turntable brackets or arms. The turntable is provided with a scale graduated in degrees and furnished with stops and a clamp. The right hand trunnion bearing is also graduated in degrees for tilt, and the trunnion is scaled off so that the offset or traverse, given to the centre of the holder by the screw previously referred to, can be determined. Finally, this sleeve is graduated in degrees so that the holder can be set in it to any angle, and clamped.

In Table I the settings are given for the turntable, trunnion and tool-holder. We do not propose to give exact instructions for obtaining these shapes and angles with this machine, and have, therefore, omitted from Table I several additional indications which assist in the quick setting-up of the holder for any selected shape; but, by taking one or two examples, it will be easier to show how the work is taken in hand. Take, for instance, the right-hand roughing tool No. 4, the first operation is the grinding of the face 1. To do this, the turntable is set at 35 deg., the holder is tilted on the trunnions 6 deg., and the tool-holder is turned to bring the side of the tool 6 deg. over from the vertical. The two latter, together, give the clearance and maintain the cutting edge horizontal. The second operation is the backing off of the face 2, which is done with a turntable setting of 50 deg., and a tilt of 6 deg. in the

trunnions. The top face is ground with a turntable setting of 15 deg., which is the angle measured from front to back of the tool, but this is combined with a side-cutting angle of 22 deg. obtained by revolving the toolholder in the sleeve.

In many of the tools shown the object of the angles, as given, is obvious. For instance, for No. 11 the second and third operations give a small relief in both the horizontal and vertical planes; the same is the case of No. 20. Another class of operations is typified by the second for No. 8, in which the tool-holder is tilted sideways in the sleeve 6 deg. to give vertical side clearance combined with a straight edge. Clearance in front necessarily involves the tilting up or down, according to the operation, of the tool-holder in the trunnions. Tool No. 11, Op. 1 is typical of the simplest case. More frequently the cutting edge is set at an angle, and as already pointed out, the clearances involve settings both of the tool-holder in the sleeve, and also on the trunnions.

It may be mentioned that in tools such as Nos. 1, 2 and 3, the side-curve is struck as a rule to a radius equal to the width of the tool, the holder being traversed on the trunnions to an amount equal to this width, the side being first ground off to the 10 deg. setting, after which the whole turntable is swept round, so as to work towards the point. The point may be either rounded off to 6 deg. clearance on the machine, or by hand on a plain grinder. The machine is recommended for large tools. Tools with radii such as are shown in the list as No. 24 and No. 25, are ground with the assistance of a radius gauge. This gauge takes the form of an L of steel, one arm of which is graduated and is a sliding fit in a horizontal holder on the side of one of the turntable brackets. The gauge is set so that the scale reads to the radius required, and the tool is set in the holder (canted to the proper clearance) so as to touch it. The effect of this is that the tool edge to be ground projects beyond the turntable centre an amount equal to the radius chosen. At the same time the holder is traversed in the trunnions an amount equal to the radius, when the swinging of the turntable ensures a corresponding radius being ground on the tool.

A tool of the type of No. 12, which has a curved top face has to be treated differently from others shown in Table I, though many of the others are also well adapted for curved top rake, which type of grinding will be gone into in greater detail in a subsequent article.

(*To be continued.*)

DEVELOPMENT OF POWER ALCOHOL.—The Alcohol Fuel Corporation, Limited, 7, Princes-street, Westminster, S.W. 1, state that as a consequence of the removal of the duties and restrictions on the importation and manufacture of power alcohol, they hope shortly to put into operation the preliminary arrangements they have made for the production and sale of Natalite motor spirit in the United Kingdom. In this connection, Mr. E. S. Shrapnell-Smith, Mr. Geo. W. Watson, Mr. H. G. A. Harding, and Mr. J. Stanley Arthur, have been retained as technical advisers to the corporation.

THE AERSEDCON SEWAGE PURIFICATION SYSTEM.—An installation has recently been put into commission at Olantigh Towers, near Wye, the seat of Mr. W. E. Sawbridge Erle-Drax, for dealing with domestic sewage on the system of the Aersedcon Sewage Purification Plant Company, 9, Southampton-street, Holborn, W.C. 1. This system has been worked out by Major Hilder Daw. In the installation in question rain water is excluded from the drainage system, and after septicisation river water is added, the watered sewage passing to a storage tank. From this it is raised by a *chaine helice* pump to a point at which there is a control valve. The pump raises some 30 times the quantity passing the valve so that the rejected sewage is well aerated and the solids broken up, in being returned to the tank. This process is assisted by a current of air directed against the falling stream. The pump takes about ¼ h.p. and is driven by a neighbouring stream, and works continuously. From the control valve the sewage passes to a sedimentation chamber, the septic gases being diverted to a scum chamber. The sludge slides into a separate chamber, which it is expected will require clearing only about once a year. This sludge chamber may be cut off from the rest of the plant by valves, so that the level in the sedimentation chamber is not disturbed. From the outlet of the sedimentation chamber the clarified sewage passes to a weighted tipping tray discharger. By the arrangement of one set of weights the tray, as soon as filled and emptied, is returned to its original position so that one side of the filter bed only is in use at a time, thus obviating a spare bed. By means of other weights the tipping can be adjusted to occur with the liquid at different levels so that the quantity per discharge may be regulated, and adjusted to the character of the sewage. The beds are divided into small vertical compartments and, when flooded, the sinking liquid carries down fresh air before it. The whole installation is compact. It is continuous in operation. The plant which will deal with 1,000 gallons to 2,000 gallons per diem, has been constructed by the estate foreman, with the assistance of one man, to the plans supplied by the Aersedcon Sewage Purification Plant Company.

SWAGING AND SIDE-DRESSING MACHINE FOR BAND SAWS.

AN automatic machine for swaging and side-dressing the teeth of band saws is illustrated in the figures on page 188. The machine, which is constructed by Messrs. A. Ransome and Co., Limited, of Stanley Works, Newark-on-Trent, can deal with saws from 3½ in. to 8 in. wide and with teeth from 1½ in. to 2½ in. pitch. It is entirely automatic in operation and works at the rate of 20 teeth a minute. The machine is self-contained on a cast-iron bedplate and is adapted for bolting to the wooden bench which is usually provided for the setting frame. It is belt driven, 12 in. diameter fast and loose pulleys being provided on the driving shaft, which runs at 80 r.p.m. The swaging and side-dressing operations are carried out by independent parts of the machine, one tooth being swaged while another is being side-dressed. The operation is quite satisfactory even if the teeth of the saw being dealt with are not exactly of equal pitch.

The details of the machine will be followed from the illustrations. Of these, Figs. 1 and 2 are general views, while Figs. 3 to 9 give a series of elevations and plan. Figs. 1 and 2 are identical except that in the case of the latter a saw is shown in position for treatment. As will be seen the saw rests on a guide bar which can be adjusted up and down to suit the width of saw, or the depth of tooth. This adjustment is carried out by the hand-wheel which is indicated by *a* in Fig. 4. The saw is held up against the back plate by a spring clamp which can be seen to the left in Figs. 1 and 2. The side-dressing mechanism is mounted immediately above this clamp, while the swaging mechanism is situated to the right of it. The latter mechanism consists of an adjustable anvil which rests on the top of the tooth being swaged, and a rocking eccentric die which operates on the face of the tooth. The saw is prevented from sliding in the spring clamp during this operation by a stop screw which bears on the back of a tooth, while it is supported sideways by a cramp which can be seen in Figs. 1 and 2, and is shown in elevation in Fig. 5.

The whole of this swaging mechanism is carried on a slide working on an inclined race, as is perhaps best shown in Fig. 4, in which the slide is indicated by *b*. It moves up the ways to clear the teeth as the saw is fed forward and comes down into position again as each tooth comes into place. It is operated from a cam on the main shaft, which acts on a lever motion. The cam and cam shaft are best shown in Figs. 6 and 8. The cam shaft is geared to the driving shaft as can be seen in several of the figures, and as shown in Figs. 1 and 2 the driving shaft is fitted with a hand-wheel for use while setting-up. The saw is fed forward after each tooth has been dealt with by a push rod mounted on a rocking arm shown at *c*, in Fig. 4, and operated from the same cam mechanism.

The side-dressing device consists of two hinged arms which hold dies for shaping the sides of the swaged teeth and making every tooth the same width. These arms, which are indicated at *d*, in Figs. 3 and 4, are carried on a head which has vertical and horizontal adjustment. They are closed together on to the tooth to be dressed by a pair of conical rollers carried on a rocking shaft. These rollers can be seen in Figs. 1, 2 and 4. The rollers first push the arms back firmly against an adjustable stop and then close them on to the tooth. After the operation of side dressing the arms re-open automatically ready for the travel of the next tooth into position. As before mentioned, while one tooth is being swaged one that has been treated earlier is being side-dressed. The side-dressing mechanism is operated from the same cam and lever motion of which details are more particularly given in Figs. 7 and 8. The width of the saw teeth can be regulated by adjusting the swivelling bracket carrying the arms up or down its slide by means of the hand-wheel *e*. A fine adjustment is also provided by means of the stop screw against which the arms rock.

DRAFT OF THE SPANISH TARIFF.—The Board of Trade has issued as a supplement to the *Board of Trade Journal* the draft of the proposed new Spanish tariff. This draft tariff is published for general information, and, up to September 8, the Spanish Customs Board will be prepared to receive representations and petitions on the subject of the tariff proposals. These may be submitted in writing by industrial or commercial bodies, or private individuals, who may consider their interests to be affected by the proposals. At the end of the period the draft tariff, together with all representations received will be reviewed by the Customs Board, who will, as soon as possible thereafter, submit to the Spanish Government the definitive draft of a new tariff. The Board of Trade propose to invite Chambers of Commerce and trade associations in the United Kingdom to submit to them any representations which those bodies may desire to make in the interests of the trade of their members, with a view to such representations as may appear to be necessary being made officially to the Spanish Government with regard to the proposed new tariff in relation to the trade of this country with Spain.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—An improvement in home and export business in engineering products is looked for as the result of the ability of manufacturers to quote more attractive prices in competition for contracts. This ability arises from negotiations extending over practically the whole of the heavy engineering branches. Representatives of employers and of trade unions alike have been impressed by the fact that if the stagnation in trade is to be arrested and buyers are to be induced to place new orders, production costs must be severely cut. Consequently agreements have been arrived at covering important branches of the South Yorkshire engineering trades, whereby wages immediately, or in the near future will be reduced from 15 per cent. to 17½ per cent. Similar efforts are being made to place the crucible steel trade on a firm basis, though at present the workers are kicking against the suggested return to the pre-war practice of three rounds daily. Sharp contrasts are presented in the condition of trade in railway rolling-stock and materials. A few of the more fortunate concerns are employing complete staffs on full time; others have booked next to no business during the past six months, and are beginning to show signs of anxiety at the absence of orders from British undertakings. The spring trades, both coil and laminated, are worked at unusually low pressure. Electrical undertakings report that Continental competition for new business has never been keener. Manufacturers are exerting their utmost efforts to enforce economies and reduce costs, but are not helped by trade union insistence on the retention of war practices, which hamper and delay output. Makers of steel works plant present a hopeful front. New bookings are by no means abundant, but there is a greater reserve of orders here than probably in any other section of the engineering trades locally. Makers of edge tools, scythes and sickles expect to benefit in the early autumn from the operation of revised wages scales. The market in raw and semi-finished materials offers no new feature except that the margin in prices tends to contract, thus paving the way for firm quotations.

South Yorkshire Coal Trade.—Pits in this area have got fairly into stride again. Outputs on the whole are satisfactory, though in certain cases considerably below the pre-strike level. The demands of gas companies, railway companies, and public utility works absorb the major portion of supplies. Industrial users are not taking a large tonnage, though requirements tend to expand. The slump in coke-making is largely responsible for a renewed accumulation of slacks at the pits. Special lots are on offer at cheap rates at collieries where the managements are anxious to keep the workings clear. The contraction in the demand for house coal is more marked than a week ago. Following the action of certain collieries in declining to charge more than the pre-strike prices, the opinion has gained strength among consumers that lower rates may be looked for. Prices of all classes of fuel vary too greatly for quotations to be usefully given.

SCIENCE SCHOLARSHIPS AND EXHIBITIONS.—The Board of Education has now issued the regulations for scholarships and other awards in science for the year 1921. The pamphlet containing full details is published by H.M. Stationery Office and is numbered [Cmd. 1406]. Its price is 1*d.*, and it can be obtained either through the trade or direct from the official stationery offices in London, Manchester, Cardiff and Edinburgh, and also from Messrs. E. Ponsonby, in Dublin.

MIXTURE OF COKE BREEZE AND BITUMINOUS COAL FOR HAND-FIRED BOILERS.—The paper No. 2,244 issued by the United States Bureau of Mines applies to tests made to determine the value of a mixture of coke breeze and bituminous coal as a fuel for hand-fired heating boilers. The tests were made on a cast-iron sectional boiler, having the following features:—

Grate area	32·5 sq. ft.
Width of air spaces in grate area	¼ in.
Proportion of air space in grate area	31 per cent.
Heating surface	815 sq. ft.
Rated output per hour ...	3,780,000 B.Th.U.
Volume of mixing chamber...	20 cub. ft.
Volume of combustion chamber	36 cub. ft.
Mean height from grate to furnace roof	32 in.
Volume of furnace	93 cub. ft.

The fuel was a mixture in equal parts of Pittsburgh run-of-mine coal and coke from by-product coke ovens. Tests were made using both coarse and fine breeze. The average calorific value was about 12,900 B.Th.U. per pound for the coal and 970 B.Th.U. for the coke breeze. The mixture of Pittsburgh coal and coarse coke breeze gave less than one-half the smoke given out by the coal alone, about 20 per cent. less steam and required a stronger draught. The steaming value of the coarse breeze was about 70 per cent. of that of the coal, so that to compete with the latter, allowing for the possible necessity of using steam jets to give the required draught, it should cost less than 70 per cent. as much. At a low rate of steaming, the mixture with the fine coke breeze showed practically the same efficiency and draught as that with the coarse. However, the draught required rose very rapidly and efficiency fell considerably at increased loads, whilst the amount of smoke produced became considerably greater than for the coarse breeze. For these reasons, the fine breeze is recommended only for use at low rates of combustion.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Furnaces are getting to work very slowly after their long enforced idleness, and there seems no likelihood of general resumption of production of pig-iron until coke has been very substantially reduced in price. Five blast furnaces are now operating and making basic iron for consumption at steel works owned by the proprietors of the furnaces. One blast furnace is being blown in to make Cleveland foundry pig-iron for sale in the open market, and the same firm hope to rekindle a second furnace very shortly. No. 1 Cleveland pig-iron is altogether unobtainable, and No. 3 is becoming very scarce. Limited parcels of the latter can now be purchased only by buying at the same time equal quantities of No. 4 foundry. The prompt home price of No. 3 and foundry 4 is 135*s.*, and the export price 140*s.* For August delivery, 5*s.* above the foregoing quotations has to be paid. Makers have still heavy stocks of the lower qualities of Cleveland pig-iron, and are keen sellers at 117*s.* 6*d.* for No. 4 forge and mottled, and 115*s.* for white iron.

Hematite.—No movement in the direction of restarting hematite furnaces is noticeable. Supply of hematite iron, however, is plentiful. Nos. 1, 2 and 3 East Coast brands are on offer at 160*s.* for home consumption, and 140*s.* for shipment to foreign destinations.

Foreign Ore.—There is no market for foreign ore. Consumers have heavy stocks, bought at high figures, and substantial deliveries to take against old contracts.

Coke.—Blast-furnace coke is on sale at 45*s.* delivered, but local consumers consider that fully 10*s.* above the figure they should be charged.

Manufactured Iron and Steel.—In finished iron and steel new orders are difficult to secure, but there is a slightly better feeling, and manufacturers have a fair amount of arrears of work to execute. Keen Continental competition is still successful, but the opinion prevails that the next out in prices here may result in substantial orders being realised, many of which are expected to be booked by firms in this district. Common iron bars are 16*l.*; marked bars, 20*l.*; steel billets, 11*l.* 10*s.* to 12*l.* 10*s.*; steel boiler plates, 21*l.*; steel ship, bridge and tank plates, 15*l.*; steel angles and joists, 14*l.* 10*s.*; heavy steel rails, 14*l.*; fishplates and sleepers, 19*l.*; black sheets, 19*l.*; and corrugated galvanised sheets, 23*l.* 10*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

State of Trade.—There is a better trade feeling throughout the country, and an early improvement is being looked for, but so far nothing much in the way of new business has been fixed up. This is the holiday month, and many industries which were either closed down, or partially so, during the coal strike are not likely to be doing much until well into August. Work in the Greenock area has commenced, and by the beginning of next week works in and around Glasgow will be started up although full employment is not likely for a week or two. Dundee and Edinburgh and Leith districts are on holiday this week, while next week Paisley and Kilmarnock districts will be closed down so that it will be nearing the end of August before the general industry of the country is in full operation. By that time fuel may be cheaper and prices all over become easier and business open out both on home and export account.

Scottish Iron and Steel Trades.—With the holiday period not yet over there is practically nothing doing in the iron and steel trades of Scotland this week. The booking of fresh orders has not been on a large scale during the stoppage, and few firms have much in the way of business to commence with when their works open. The disastrous effects of the miners' strike will long be felt, and it will be many a day before the old state of affairs will prevail, although these times will assuredly come back. Supplies of fuel are beginning to get more plentiful, but not until an appreciable drop takes place in prices can the general trade be expected to open out. To-day's quotations are much too high to permit of the iron and steel producers reducing their prices to any extent in the meantime, but the moment coal shows signs of weakening, there is every prospect that local iron and steel will be cut in price in order to secure some of the business at present going to the Continental makers. Inquiries are beginning to show some improvement, but those with orders to give out are very slow to fix up, particularly when they consider that a little further delay will be advantageous to them. Prices show no change, and are as follows:—Steel: Boiler plates, 20*l.* per ton; ship plates, $\frac{3}{8}$ in. and up, 15*l.* per ton; sections, 14*l.* 10*s.* per ton; sheets, $\frac{5}{16}$ in. to $\frac{1}{4}$ in., 16*l.* 5*s.* per ton. Iron: "Crown" bars, 16*l.* per ton, all net, delivered Glasgow.

Scottish Pig-Iron Trade.—Business in the pig-iron market is exceedingly quiet, and as fair stocks are still available makers are in no desperate hurry to relight their furnaces owing to the high figure being asked for fuel. The demand for foundry iron has been very steady and some grades are now off the market, and while there are still fair supplies of forge iron it also is becoming scarce. Steel makers have quite a good quantity of hematite iron on hand, but whenever they start moving there will be a steady demand on makers' stocks, although the latter are expected to be able to meet all legitimate requirements. There is some cheap foreign pig-iron on offer here and the price is between 2*l.* and 3*l.* per ton under the home quotation, which is another factor against rekindling furnaces so long as oncost is so high.

Steel Nails Reduced in Price.—Intimation has just been made of a reduction in the price of steel nails amounting to 2*l.* per ton. The basis price is now 29*l.* 10*s.* per ton.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—At the annual conference of the South Wales Miners' Federation an important change in respect of the future position of the President of the Miners' Federation of Great Britain was recommended. It was decided that South Wales should vote in favour of the office being an annual part-time appointment. Mr. R. Smillie, it might be recalled, was a permanent president, and as such was the chief executive officer of the Federation and largely responsible for the policy of the organisation. The significance of the change is that the South Wales miners are advocating a reversal to the Smillie *regime*. It was also decided that a recommendation be made to the lodges that all workmen in employment should be asked to contribute a levy of 5 per cent. on their earnings and agree to have the same deducted and retained by the colliery companies. The conference also agreed to adopt Part II of the Mines Industry Act. Terms of settlement have been arranged and agreed upon in connection with the dispute at the collieries of the Ebbw Vale Company, and it is expected that there will be an early return to work. This is of considerable importance, for the Ebbw Vale Company control a substantial proportion of Monmouthshire coal, which had been so scarce since the national strike settlement, and a restart at these collieries will considerably augment outputs. The miners, too, are only taking one day holiday next week, and it is expected that outputs will not suffer much by the intervention of the August Bank Holiday. Meanwhile business on the coal market has been restricted by the hold-off policy which buyers have adopted in the belief that with increased outputs prices are likely to fall appreciably. Whether this view will be justified by the event remains to be seen. At any rate large coal, which a week ago was unobtainable at less than 47*s.* 6*d.*, can now be secured at 45*s.*, while smalls, which ruled round 25*s.*, are now down to 20*s.* and 22*s.* 6*d.*, with buyers talking about 40*s.* for large and 20*s.* for small in August. At the same time many collieries are reported to be fully stemmed up till the end of August and refuse to take less than 45*s.* for large and 25*s.* for small. It is reported that a considerable reduction has been effected in working costs, but the question of prices will depend on outputs.

Iron and Steel.—The new Continental import duties on tin plates and galvanised sheets have attracted the attention of Welsh makers. The new duties are regarded as detrimental to Welsh manufacturers for the increased duty will, as usual, be passed on to consumers. In cases where countries have tin and sheet works of their own these duties will help them to manufacture against the Welsh products. On the other hand, it is anticipated that there will shortly be a fall in the price of steel, and though a good number of mills are still idle, there are now about 20 per cent. in operation. Prices are steady on the basis of 24*s.* to 28*s.* per box for standard sizes with a fair inquiry from the East and the Continent.

CO-PARTNERSHIP EXHIBITION.—The Department of Overseas Trade is informed that it has been definitely decided to postpone until next year the Co-Partnership Exhibition, which was to have taken place at the Crystal Palace during the autumn. It is understood that the exhibition may be opened next July.

THE LATE MR. CHARLES JOSEPH WILLS.—We regret to have to announce the death, which occurred on the 22nd inst., at Westcott House, near Dorking, of Mr. Charles Joseph Wills, chairman of Messrs. C. J. Wills and Sons, Limited, and managing partner of Messrs. Price, Wills and Reeves, public works contractors, Victoria-street, Westminster, S.W. 1. Mr. Wills had undertaken the construction of a number of railways and docks both at home and abroad, including a section of the Manchester Ship Canal, the Barry Docks, the Fraserburgh Harbour Works, the Heysham Harbour Works, the Immingham Docks, the Famagusta (Cyprus) Harbour Works, breakwaters at Port Said, and docks in Bombay. During the war he carried out heavy engineering works in connection with fortifications, submarine defence works, and oil fuel installations for the Navy.

COPPER MINING IN QUEENSLAND.—There has latterly been a large increase in the production of copper ore in Queensland. The principal mine, that at Einasleigh, near Cairns, belongs to the State. An official report just issued shows that an average production of 450 tons weekly during the first half of 1920 was increased to upwards of 500 tons weekly at the close of the year. The mine holds extensive ore reserves and is capable of a further substantial output for a lengthened period. Its increased activity is due largely to the reopening of the Chillagoe Smelting Works as a State concern. The next most important producer is the Empress mine at Herberton, last year's output having neared 2,799 tons. This carries 10 per cent. of copper and 9 oz. of silver per ton of ore. The output for the current year depends upon the value of the metal, and that applies to all the mines of the district. Of the smaller mines the New Lady Mary, near Silverfield; the Rio Tinto, at Mount Albion; the Agnes and Slommicker, at Silver Valley; Carman Brothers' Mine, Mount Emma; and the United North Australian, Watsonville, accounted last year for about 50 tons of copper.

NOTICE OF MEETING.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, August 5, at 39, Victoria-street, Westminster, S.W. 1. Paper, "Flax—Its Cultivation and Manufacture" (slides and exhibits), by Mr. C. R. Turner, Member.

METRIC SYSTEM IN JAPAN.

THE Board of Trade state they have now obtained a translation of the recent Japanese Law (number 71 of 1921), the object of which is the ultimate substitution of the metric system of weights and measures for the present Japanese system.

Among the provisions of the new Law are:—

Article 1.—The unit of measurement shall be the metre and the unit of weight the kilogramme [these are substituted for the "shaku" and the "kwan"].

Article 2.—The metre shall be determined by the standard metre delivered to the Imperial Government in accordance with the Metric Treaty, and the kilogramme by the standard kilogramme delivered to the Imperial Government according to the Metric Treaty.

Article 5, Clause 2.—This provides that weights and measures or standards of measurement not in accordance with the new Law, or with Imperial Ordinances based on that Law, may not be used in business transactions or for purposes of certification unless otherwise determined by Imperial Ordinances.

Articles 6 to 14.—In the old Law these imposed certain restrictions on the manufacture and sale of weighing and measuring appliances, provided for the official inspection of such appliances, and set up regulations regarding the sale of goods marked with their net weight. In the new Law these are all retained.

Penalties.—Among the penalty sections of the Law, it is provided by Article 15 that persons infringing Clause 2 of Article 5 above are liable to a fine not exceeding 100 yen or a police fine.

Supplementary Articles.—The date of enforcement of this Law shall be determined by Imperial Ordinance.

The weights and measures in common use hitherto may continue in use for such period as will be determined by Imperial Ordinance.

A copy of the Law may be inspected at the Department of Overseas Trade (Development and Intelligence), 35, Old Queen-street, London, S.W. 1.

INFORMATION ON ROUMANIAN PORTS.—The Commercial Attaché of the Roumanian Legation in London has notified the Department of Overseas Trade that the Chambers of Commerce at Braila, Galatz and Constantza have signified their willingness to supply by letter or cable any kind of information required by British shippers and shipowners as to the conditions at those ports with regard to loading and unloading facilities. The Department receives from time to time such reports from the Commercial Secretary to H.M. Legation at Bucharest; but on occasions where it would be advantageous to obtain cabled information with regard to special facilities, the alternative above suggested may be useful.

STANDARDISATION OF BALL AND ROLLER BEARINGS.—As a result of a request received from the Ball Bearing Manufacturers' Association, a conference called by the British Engineering Standards Association met recently under the chairmanship of Colonel R. E. Crompton, to discuss the standardisation of ball and roller bearings covering the requirements of the engineering industry as a whole, the purpose of the inquiry being to ascertain, before proceeding further, whether there exists a consensus of opinion favourable to the work being undertaken. It was quickly evident that there was no doubt in the opinion of those present as to the desirability of the proposed standardisation, the only points upon which there were any discussion being in connection with the actual types of bearings to be included. A resolution was unanimously passed recommending the setting up of a Sectional Committee of the British Engineering Standards Association to undertake the work, and such a committee will, no doubt, be formed as soon as circumstances permit. This Sectional Committee will not, we understand, supersede the existing British Engineering Association committees dealing with ball bearings for automobile and aircraft purposes, but will co-operate with them.

STANDARDISATION OF FIRE HOSE COUPLINGS.—The standardisation of fire hose couplings, including gauges to be employed in their manufacture, was recently discussed at a conference called by the British Engineering Standards Association, under the chairmanship of Colonel R. E. Crompton. A request for this matter to be taken up had been received by the British Engineering Standards Association from the National Fire Brigades Association, and the calling of a conference was at once sanctioned in order to ascertain whether those interested in the matter were in favour of this standardisation being carried out. The general opinion of the conference was that, however, desirable it might be to establish a single type of coupling, it was not practicable at any rate for the present, but they were unanimously agreed that in the interests of manufacturers, users and the public services, the standardisation of the three types of fire hose couplings in general use in the country would be of great benefit, and a resolution was adopted recommending the formation of a Sectional Committee of the British Engineering Standards Association to undertake this most important work, and such a committee will doubtless be set up in due course.

AUTOMATIC SWAGING AND SIDE DRESSING MACHINE FOR BAND-SAWS.

CONSTRUCTED BY MESSRS. A. RANSOME AND CO., LIMITED, ENGINEERS, NEWARK-ON-TRENT.

(*For Description, see Page* 186.)

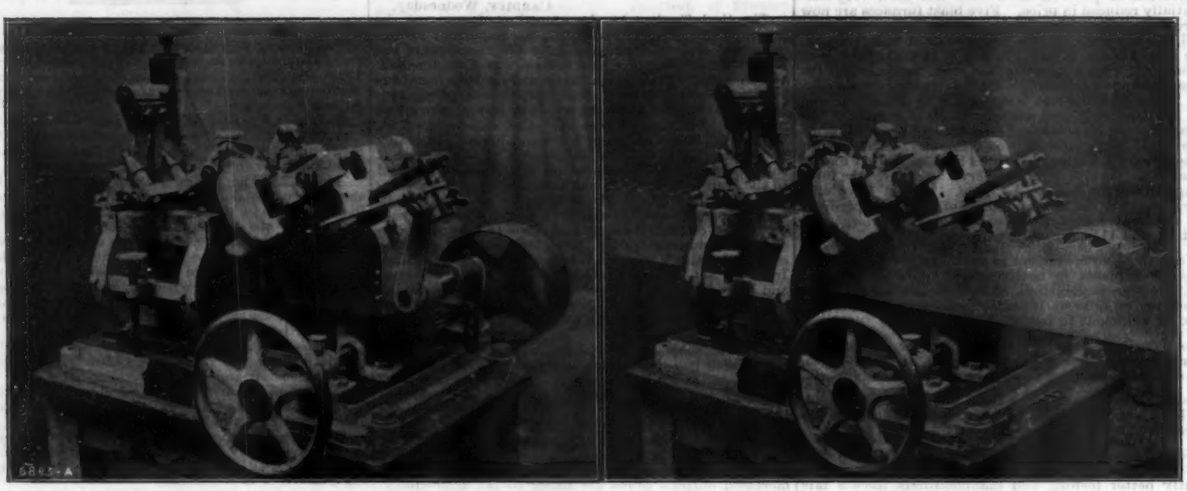
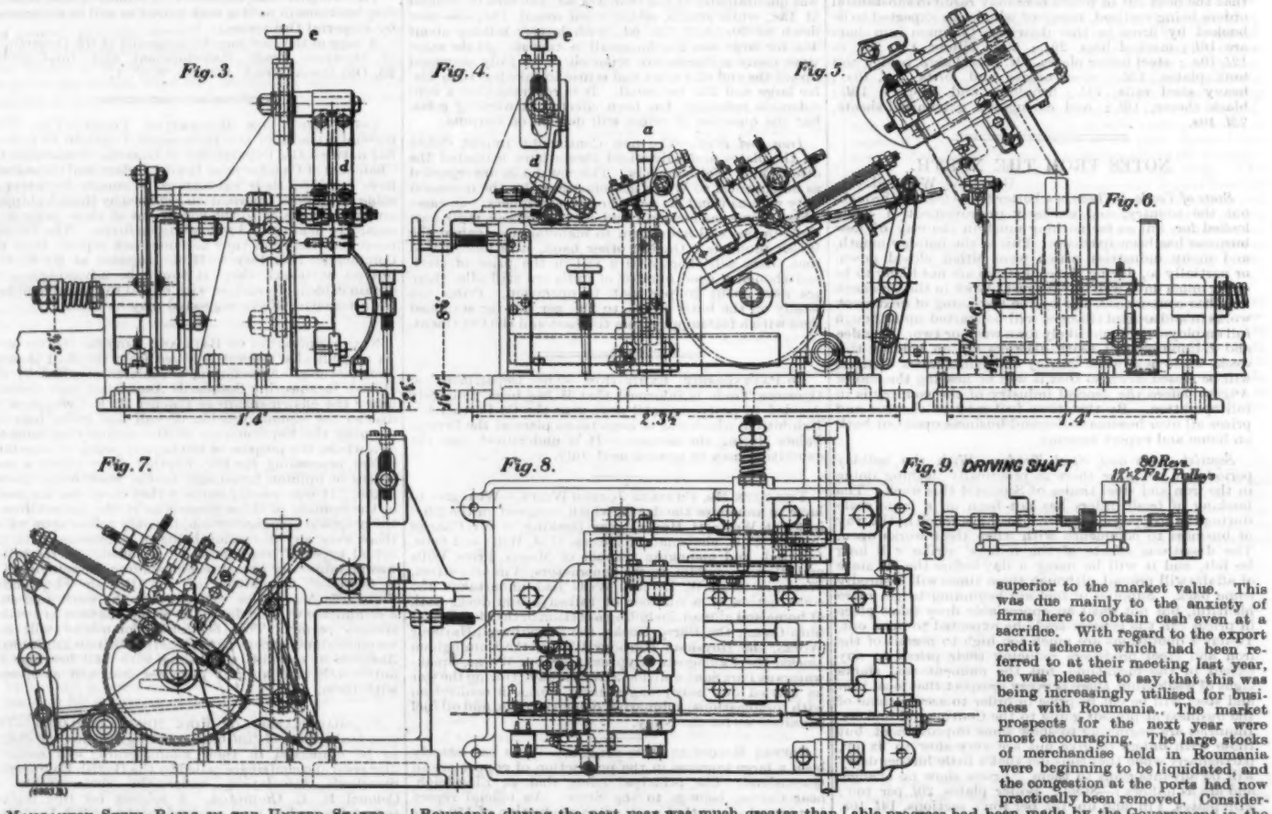


FIG. 1.

FIG. 2.



MANGANESE STEEL RAILS IN THE UNITED STATES.—We read in *Engineering News-Record*, New York, that the first shipment of 15 per cent. manganese steel rails, on an order placed by the Southern Pacific Railroad for 2,000 tons, has been laid on the Tehachepi grade in California. Rail wear over this pass has been very rapid, because a large portion of the grade is on very sharp curves, the section including the famous Tehachepi Bend. Under these conditions 90-lb. standard rails on the inside of curves have to be renewed on an average of every eighteen months. The manganese steel rails are costing about 4½ times as much as common rails.

TRADE WITH ROUMANIA.—The third annual meeting of the British Roumanian Chamber of Commerce was held at the London Chamber of Commerce on July 20. The Right Hon. Viscount Goschen, who presided, said that the value of the trade between England and Roumania during the past year was much greater than that of previous years, although those trading with Roumania had had many handicaps in marketing their goods. Amongst these handicaps, which were not peculiar to Roumania, had been the exchange fluctuations, the disorganisation of transport and falling prices at home. Roumanian merchants had been chary of importing whilst prices were unstable. In spite of these obstacles, Roumania had been on the whole, a very good market during a period of world-wide conditions of trade depression, and had clearly shown that she had a great capacity for absorbing our goods. Payments had been on a considerable scale, and, speaking generally, had been made in a satisfactory manner, although, of course, there were cases in which the settlement of debts had been adjourned. In this connection, owing to the tightness of money in this country, some English firms had lately shown a tendency to accept payment of their sterling debts in local currency at a rate of exchange superior to the market value. This was due mainly to the anxiety of firms here to obtain cash even at a sacrifice. With regard to the export credit scheme which had been referred to at their meeting last year, he was pleased to say that this was being increasingly utilised for business with Roumania. The market prospects for the next year were most encouraging. The large stocks of merchandise held in Roumania were beginning to be liquidated, and the congestion at the ports had now practically been removed. Considerable progress had been made by the Government in the reorganisation of transport by rail. This and the good harvest prospects were probably the most gratifying features of the present position, and, following the unification of the currency which had been nearly completed, greater activity could be looked for. This would be more especially the case if trading relations were resumed between Russia and Roumania, in which case a large proportion of the existing stocks in Roumania would be quickly disposed of.

BRUSSELS MOTOR SHOW.—The Department of Overseas Trade, 35, Old Queen-street, S.W. 1, is informed that applications for space at the Brussels Motor Exhibition, to be held from December 3 to 14, should be addressed to the Comité Exécutif du Salon, 80, Rue de Namur, Brussels, not later than August 17.

THE TURBINE DRIVEN QUADRUPLE-SCREW

CONSTRUCTED BY THE SOCIÉTÉ ANONYME DES CHANT

(For Description, see Page

Fig. 12. DECK D

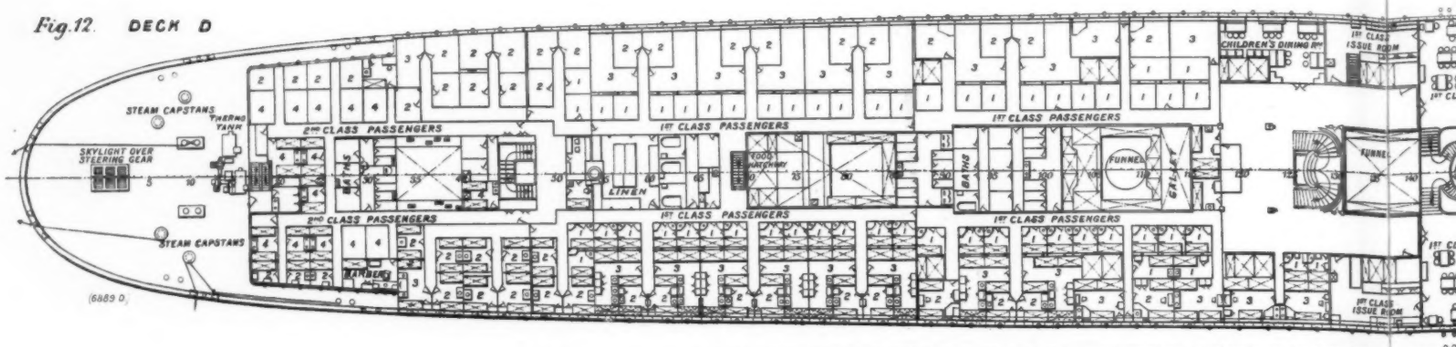


Fig. 13. DECK E.

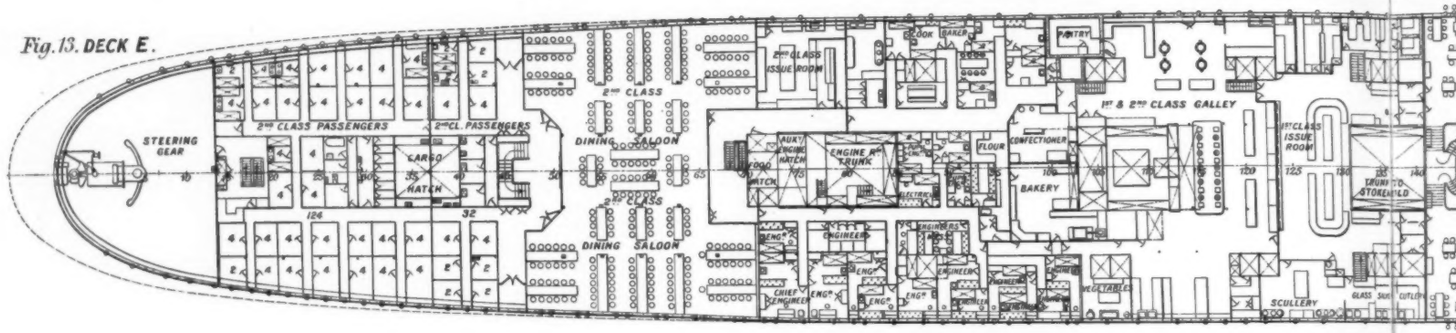


Fig. 14. DECK F.

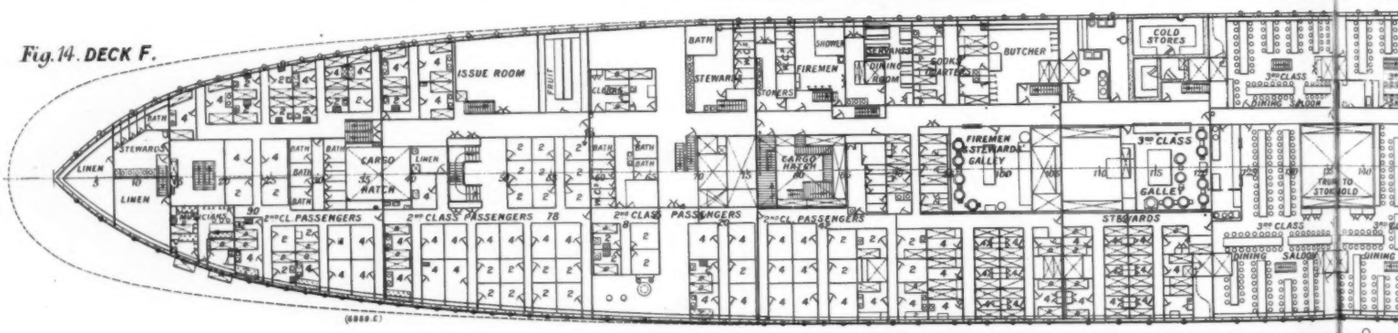


Fig. 15. DECK G.

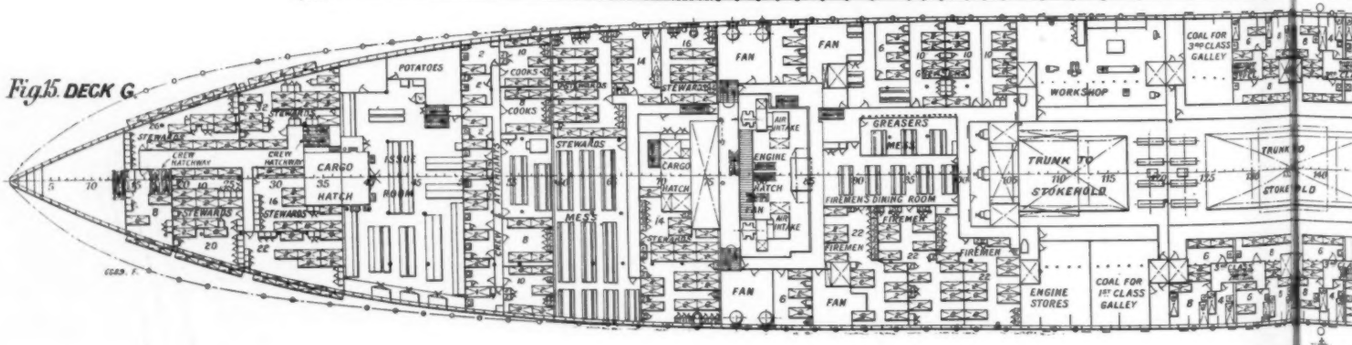
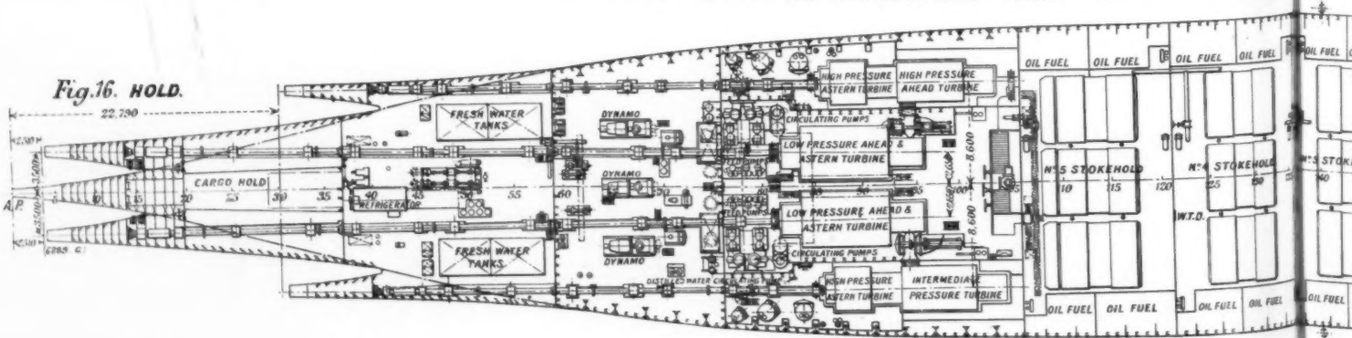


Fig. 16. HOLD.



SCREW TRANSATLANTIC LINER "PARIS."

DES CHANTIER ET ATELIERS DE ST. NAZAIRE.

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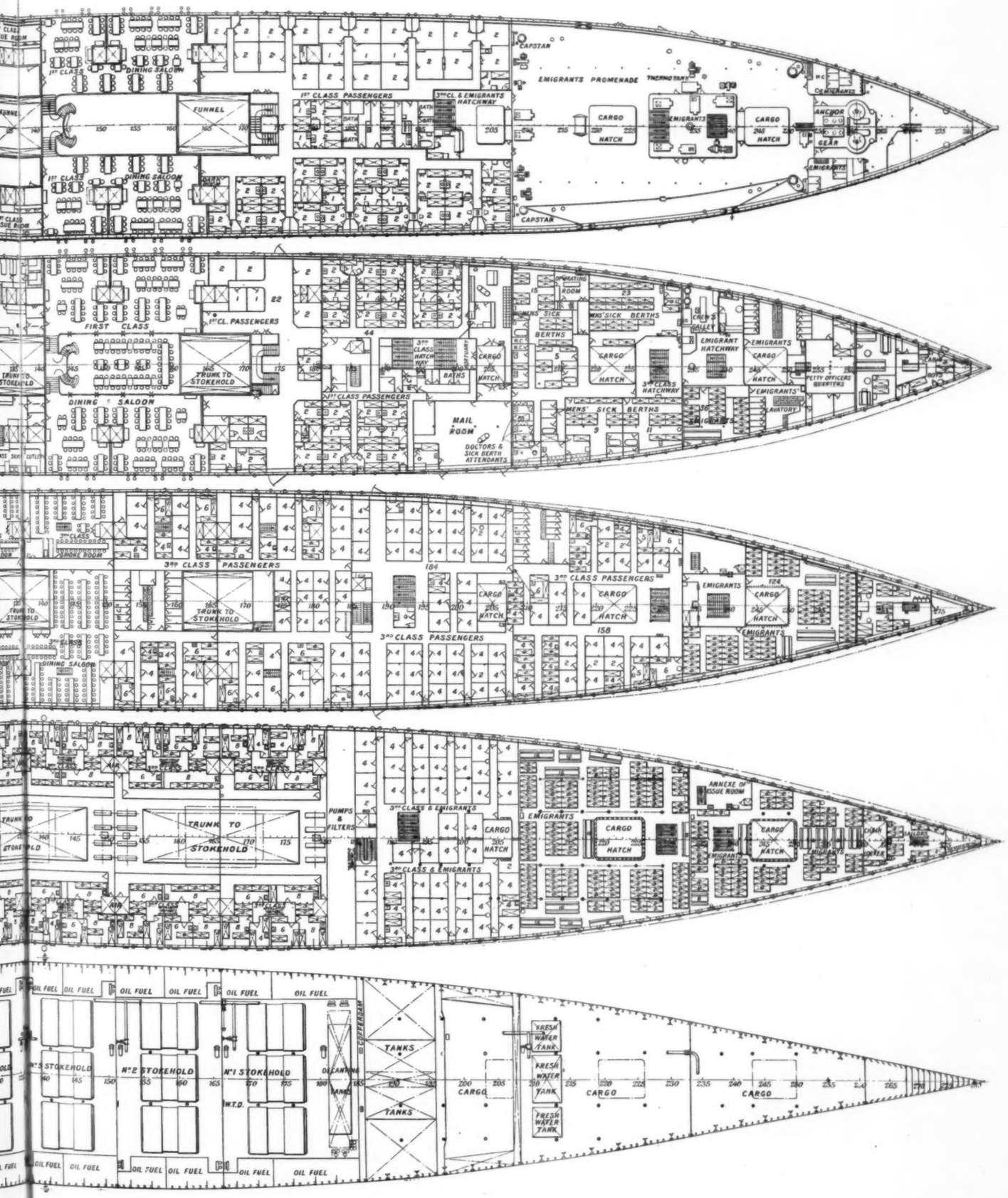

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ADVERTISEMENT RATES.

Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received on the Friday previous to the day of publication.

The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway bookstalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£3 5 0
For Canada—	
Thin paper copies	£2 18 6
Thick paper copies	£3 3 0
For all other places abroad—	
Thin paper copies	£3 3 0
Thick paper copies	£3 7 6

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "The National Provincial and Union Bank of England, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford Street, Strand, W.C.2.

Offices for Publication and Advertisements 35 and 36, Bedford Street, Strand, London, W.C.2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the TURBINE-DRIVEN QUADRUPLE-SCREW TRANSATLANTIC LINER "PARIS."

ENGINEERING.

FRIDAY, JULY 29, 1921.

IMPACT STRESSES.

WHEN accumulated experience proved that structures were more severely tried by varying than by steady loads, an explanation was naturally sought for, and many engineers adopted the view that the decrease of resistance observed was due to impact, basing their conclusions on the readily demonstrated fact that if a load be suddenly applied to a structure the deflection produced is greater than if applied very gradually and slowly. On this hypothesis, therefore, the safe working stress is the same under either a dead load or a live one, but in the latter case the real stress is very materially higher than the nominal one. This view was supported by no trustworthy observations or experiments. Indeed, if our memory serves us, tests made for the Railway Commissioners of 1847 appeared to negative the theory that the stress arising in a railway bridge under service conditions could ever be seriously augmented by impact. In 1848, moreover, James Thomson showed that the range of stress on a material was nearly as important as the maximum value of the stress, and this conclusion was confirmed by the subsequent work of Fairbairn, Wöhler and Bauschinger. To the latter, indeed, the discovery is commonly attributed, Thomson's demonstration being ignored.

On this view a live load which produces no higher stress than a dead one may nevertheless be more dangerous, whilst those who believe in the importance of impact are, if logically consistent, compelled to argue that the safe limit of stress is independent of the range of the stress, but that under live loads the real stresses are very much higher than the nominal. No conclusive evidence in support of this conclusion has as yet been forthcoming, and indeed the exceeding careful experiments on the bridges of the Western of France Railway made by M. Rabut in the "nineties" of the last century appeared to controvert the theory, but as some specifications were issued in America in which an "impact factor" was prominently embodied, other engineers have thought it necessary to follow suit, instead of making inquiry amongst maintenance engineers as to whether practical experience afforded any support for the principle.

Experiments on the actual stresses produced in a railway bridge by a moving load are exceedingly difficult to make with any accuracy. M. Rabut found that it was necessary to reduce to a minimum the inertia of his apparatus or extremely fallacious results were recorded. Moreover, it is seldom or ever practicable to measure the strain along the mean fibre of a member. The instrument must in general be applied to one side, a plan which even in simple tension testing is recognised as unreliable. Finally, superimposed upon the true strain curve are commonly to be found vibrations of very considerable amplitude, the interpretation of which is by no means easy. Believers in large impact factors hold that the maximum stress is measured by the half amplitude of the maximum vibration added to the mean strain curve, but have as yet provided no evidence that this conclusion is correct nor that even if it be correct that stresses maintained only momentarily are directly comparable in seriousness with dead load stresses of equal intensity. In short the advocates of large impact factors base their views upon these two postulates, neither of which they have as yet attempted to prove. As a matter of fact, it is at least possible, in the absence of direct evidence to the contrary, that the vibrations superimposed on the mean strain curve may really be due to transverse vibrations in the member of which the elongation or compression is being measured. Moreover, in certain cases the vibrations are due in part at least to the stress recorder itself.

Unfortunately, it would seem from the report* to the Ministry of Transport just issued by Major Mount, that the Board of Trade are inclined to follow the American lead and to compel railway engineers in this country to introduce an impact factor into their specifications.

The report describes the results of 181 experiments on railway bridges in which an attempt was made to determine with the aid of the Fereday-Palmer stress recorder (see ENGINEERING, Jan. 30, 1920, page 138) the actual stresses developed in bridge members under high-speed traffic. The bridges tested ranged in span from 15 ft. up to 146 ft. 8 in., and included types having ballasted, unballasted or jack arch floors. The travelling load consisted of two engines coupled one behind the other and the speeds ranged from 1½ up to (in one instance) 84 m.p.h.

A large selection of the records obtained are reproduced in the report. On this head we should like to make one criticism, viz., that the horizontal scale is much too open, and that the records could be more easily and accurately measured were it reduced by 50 per cent. or more.

Owing to this inconveniently long scale, we have only been able to measure up a few of these records using for the purpose a T-square with a celluloid blade, having a fine line scribed on its under surface. This line was first brought into coincidence with the line of zero strains and then afterwards into coincidence with the strains recorded, a micrometer adjustment being provided to this end. A vernier moving over a steel scale gave the height of the record to $\frac{1}{100}$ in. Taking the true impact factor as represented by the ratio of the maximum height of the mean curve recorded at the highest speed to the maximum height recorded at 1½ to 2 m.p.h., this ratio did not exceed 10 per cent. in any one of the few curves we have been able to measure, although from the same curves the reporter estimates an impact factor of from 40 per cent. to 70 per cent. These latter figures, however, are obtained on the unproven assumption that the half amplitude of the vibrations must be added to the mean curve in order to get the true measure of the danger. As matters stand, this conclusion is illegitimate as it is not shown that the vibrations were really due to extensions and compressions of the fibres, and they may have been due to transverse vibrations of the member which would similarly affect the record. In any case our materials of construction being such as they are, a momentary strain has not the same significance as a steadily maintained one. A time factor enters into all such questions as the connection between strength and stress or strength and strain. Thus wax impressions of seals found in Egyptian tombs are said in the course of the millenniums which have elapsed since they were fresh, to have run down under their own weight just as if they had been so much water, though there is no doubt that they would have shown considerable elasticity of form if subjected to a sudden distortion only momentarily maintained.

If these considerations be ignored, and the vibrations added to the mean curve, we get the same impact factor as the reporter, whose measurements are, it is stated, well represented by the formula

$$I = \frac{120}{L + 90}.$$

Here I denotes the factor by which the live load must be multiplied in order to reduce it to an equivalent dead load, and L denotes the length in feet of the structure.

In order to avoid misapprehension it may perhaps be as well to state that we do not in any way question the policy of making a distinction between live and dead load stresses, but merely the wisdom of effecting this by an impact factor. Such a method is demonstrably irrational since Wöhler proved fifty years ago that even in the complete absence of impact, live load stresses were much more serious than dead load stresses. In our view, in no case have the experiments described in the report demonstrated an impact factor in excess of some 10 per cent. Were the official interpretation of the records correct, a very much greater distinction would have to be made between live load and dead load stresses than is proposed in the report. If, as

* "Tests on Railway Bridges in respect of Impact Effect." H.M. Stationery Office. [Price 15s. net.]

is there assumed the actual stress attained is some 70 per cent. or more greater than the nominal, we ought not merely to allow for this additional 70 per cent. in comparing a live load with a dead load stress, but should make a further large reduction in our permissible working stresses in order to make provision for the fact that the stress is not a steady one.

One rather curious remark is made by the reporter with reference to the formula for impact which is embodied in the Pencoyd specification. He observes that "Our tests appear to confirm that it does not provide sufficiently for floor members and small spans." Now this is a question which could not in the very nature of things be settled by any such tests as those described in the report, since the matter is one which can be decided solely by prolonged experience of the behaviour of such short spans in actual service. The only men who could make an authoritative statement on this point are the engineers responsible for maintenance. In another part of the report Major Mount again seems to assume that there is some *a priori* method of determining safe and reasonable working stresses, as he observes that the records obtained indicated in certain cases the existence of considerable secondary stresses, and he suggests that additional metal should be provided in future similar designs if the total stress is to be kept below 8 tons per sq. in. As Professor Unwin pointed out in discussing the classical paper on "Masonry Dams," read by Messrs. Wilson and Gore before the Institution of Civil Engineers, in 1907, such a procedure is wholly illogical. MM. Sazilly and Delocre, the originators of the rational design of masonry dams, in order to determine what working stress might be legitimately adopted, computed the actual stresses attained in certain Spanish dams which had endured for centuries. They quite properly and prudently fixed their own limit of working stress at a somewhat lower figure, since the material was being used in not precisely identical conditions. Later on, when a number of the modern type of dam were already in existence, it was observed that the real stress on the masonry was somewhat higher than the originators of this type had believed, and certain engineers accordingly instead of arguing that the success of the early structures showed that this additional stress could be safely carried, claimed that additional material should be added in order to bring the true stress down to the limit provisionally assumed. Major Mount's suggestion is certainly open to the interpretation that he is an advocate of this irrational policy. If tests indicate the existence of large secondary stresses the proper procedure is not forthwith to add more material or to reduce or eliminate the secondary stresses, but to find out from the maintenance engineers how the structure in question is behaving in service. If this report be satisfactory there is no valid reason for increasing scantlings, whether the stress be 5 or 12 tons per sq. in. This, in fact, has been the policy adopted by shipbuilders who in this matter have been more scientific than bridge designers. When knowledge had advanced sufficiently to make practicable some estimate of the working stresses to which a ship was exposed, the builders and registration societies did not argue that because 6½ tons had been fixed by the Board of Trade as the safe working stress on steel for bridge work, therefore ships must be designed to the same limit. The plan actually adopted was to compute the stresses on ships which had proved satisfactory in service and to use the results as a basis for fixing the scantlings of new vessels.

An interesting but by no means novel point was brought out in the course of the tests. These showed that the actual stresses in our railway bridges were in nearly all cases much below the computed stresses. That this is commonly the case was discovered by M. Rabut in the inquiry to which we have already referred, and in many cases at least he proved that it was due to the fact that the bridge floor took a good deal of the stress which was assumed to be taken by one of the flanges of the girders. It may be noted that in the Menai Straits tubular bridge the floor forms an integral component of the girder. This bridge was, however, designed by a very scientific and reliable, if somewhat costly, procedure, the final design being based on a prolonged series of experiments in which numerous models were tested to destruction and strengthened where proved to be weak.

ALKALI WORKS IN 1920.

In the course of the year 1920 Mr. W. S. Curphey, who had been H.M. Chief Inspector under the Alkali Act since 1910 and an inspector since 1882, retired and Dr. T. Lewis Bailey, one of the former inspectors, has been appointed in his place. There have been other changes in the staff and administration, but not any reorganisation such as has recently taken place in the Factories and Workshops Department. Dr. Alfred C. Fryer, also an alkali inspector of thirty-nine years' service, has retired, like his chief. The new chief has further to announce the death of one of his former colleagues, Mr. Herbert Porter, whose decease took place after a short illness in February last, after he had drawn up his report. The whole annual report, we should say, which was published last week, is dated February, 1921.

Hitherto the United Kingdom has been, for the purposes of the Alkali Act, divided into seven districts, to three of which sub-districts were attached, while the inspector for Scotland, though presenting his report to the Secretary for Scotland, and not to the Ministry of Health, was co-ordinated to the inspectors. Now Mr. J. W. Young is chief inspector for Scotland, and the sub-districts have disappeared with a new demarcation of the districts. At present the headquarters of the seven districts and the chief inspectors are: (I) Wales and Ireland, Mr. H. J. Bailey, at Cardiff; (II) North England, Mr. E. Morley Fletcher, at Darlington; (III) Cheshire and part of Lancashire, vacant (the late Mr. H. Porter), at Liverpool; (IV) Midland and part of Lancashire, vacant, at Doncaster; (V) South Midland, Mr. A. C. Carter, at Birmingham; (VI) South and South-West England, Mr. R. D. Littlefield, at Exeter; (VII) East and South-East England, Mr. F. Napier Sutton, at London. Mr. S. E. Linder remains assistant to the Chief Inspector.

The successive Alkali Acts of 1881, 1892, 1906, brought increased responsibilities on the staff, which has not been enlarged. In the years 1884, 1893, 1909, 1919, the numbers of works under the Act were 1,041, 1,046, 1,263, 1,403, the number of registered processes 1,420, 1,495, 1,857, 2,288, and the numbers of inspectors 8, 8, 9, 8. In 1920 the number of works decreased to 1,383, that of processes to 2,241. General statistical information about production and employees is not given in the report, and (sulphuric and nitric) works are practically back in numbers to the figures of 1914, but the remaining works are of larger capacity than before the war. Of gas-liquor works, 56 were registered in 1914, and 107 in 1919; now the number is down to 92. Last year the Chief Inspector had to complain about restricted travelling facilities in their inspection work; this year facilities are said to have been better, but no visits were paid to works in Ireland, and the Report was written in February, as above stated.

Complaints about nuisances were more frequent than usual—the Report speaks, indeed, of "a proneness to complaint"—but the infractions were generally of short duration and due to causes other than culpable negligence, so that legal proceedings were again not taken. Our readers may remember that phrase from former articles, as well as the further remark, that complaints were due to operations of a non-registrable character, over which the alkali inspector has no jurisdiction; or to climatic influences. Thus we read that injurious fumes came from a recently-erected dye manufactory, in which no registrable process was carried on, and that in the first half of 1920 crops were absolutely ruined in rural districts far removed from any industrial areas. The public might argue that if gases diffuse less rapidly in a wet season than in dry weather, the gases are responsible, and not the weather. Three fatalities occurred in tar works. In one case the man, who was clinkering the fire of a still, was the victim apparently of carbon monoxide; he was revived by oxygen, but died 24 hours later. One man was killed when entering a mixed acid tank for cleaning; four men were badly gassed by sulphuretted hydrogen when clearing a blockage, but fortunately recovered, and the district inspector, who happened to be present, was able to investigate the case at once.

In the Alkali and Copper (Wet Process) Works the general labour difficulties and the inferior quality of the available coal made themselves particularly felt. To meet the latter Mr. Porter suggested a supply of preheated tertiary air to secure the necessary indraught on the air-supply pipe; iron pipes, 4 in. in diameter, were found to answer best for this purpose, though their life is somewhat short. Faulty furnace design gave trouble in some salt-cake works.

The 50 cement works open during the year were unable to satisfy the demand, owing to the difficulty of completing repairs of the rotary kilns (which gave a better atmosphere than the old shaft kilns) and of the machinery. Progress in the recovery of potash from the kiln dust is very slow; recovery was only about to commence in one factory.

As regards Tin, Arsenic and Zinc, the number of smelting works again, as in 1919, decreased by 5, being now 73. The calcination of tin ores worked satisfactorily and the 49 arsenic works (not included in the 73) also succeeded in arresting their arsenic and acid fumes. The deposition of flue dust has received considerable attention; the Report merely states that enormously extended flues are not necessarily the most satisfactory dust removers, and recommends electrostatic and other means of dust removal without giving any further information.

Arsenic works came under the Act in 1892. Prior to that date, Dr. Fryer mentions, some works discharged gases containing 7 grammes of As_2O_3 per cubic foot into the air, making the fields white. When the law stepped in, farmers were less afraid of sulphur fumes than of arsenic. The first wash towers used were packed with wooden bars of Δ-shape, well flushed with water. Then limestone scrubbers were tried; the water was sometimes difficult to provide, and more difficult still to dispose of, and half a grain of arsenic per cubic foot was left in the fumes when they entered the scrubber warm (150 deg. F.). The whole arsenic industry is centred in South-West England.

Since As_2O_3 is not readily wetted, the inspectors favoured the use of dry filters, in which the material was placed on grids; the fumes forced their way upward, and the clogged material was subsequently calcined to recover the arsenic (from 65 per cent. to 75 per cent.). The first filter material tried, brushwood, disintegrated rapidly; steel wire was found still serviceable after 128 days, whilst willow, cocoanut-fibre soaked in iron vitriol and asbestos millboard had only lasted two weeks, and vertically-suspended steel rods removed the arsenic quite as efficiently as wires. When, with an increasing demand for arsenic, more mundic (arsenical pyrite) was imported, the sulphur acidity became high, and attempts were renewed to improve the limestone scrubbers and to make the effluent from the scrubbers innocuous. The limestone answered when the fumes were first cooled in wooden bar-towers; the hot gases dissociate the calcium bisulphite formed, which is then oxidised to sulphate and loses its efficiency; in bad cases milk of lime has been used, but that treatment is expensive. Improved supervision has much mitigated all these troubles.

The spelter industry has fallen on evil days. Half of the 13 works (8 of which are in South Wales) were reduced to half output in the early part of the year, and by the end of the year operations were almost at a standstill. The Scottish works were also idle. The calcining furnace of De Spirlet, recently introduced into England, consists of a number of superposed hearths; alternate hearths can be rotated by external means from outside.

The number of sulphuric acid works, 146 in 1918, has diminished to 136. The Mills-Packard chambers, which are of the conical externally-cooled type, and date only from 1914, continue to make way, and the general tendency is in these, as in the Opl chambers, towards reducing the chamber space. Whilst in 1885 the chamber space per pound of

sulphur burnt per 24 hours sometimes exceeded 40 cub. ft., 25 being an average, the allowance is now 8 cub. ft. only, though in old works 20 is still common. With close attention to details a further reduction seems possible, but the scientific supervision still leaves a good deal to be desired, suggestions of improvement being often met by the question: What will it cost? and not by the question: What will it profit? On the other hand the height of the chambers is being increased because water sprays are preferred to steam. Mr. Curphey's gas circulating injectors, which we described last year, have continued to give satisfaction.

According to the report the contact-process works have also decreased, from 138 in 1918 to 105 in 1920, and some of the plants are still giving trouble owing to the high acidity of the gases; only one case of electric fume precipitation is mentioned; but it is stated that electric precipitation of the dust in the sulphur burners would be desirable.

The number of ammonium salt works has only decreased by 1, from 632 in 1918 to 631 in 1920, and the larger decrease in the case of gas liquor works, 111 in 1918, 107 in 1919 and 92 in 1920, does not imply actual closing of any works. The general production of ammonia in gas, iron, shale, and coke-oven works, and in producer-gas and carbonising works, has increased a little since last year, the totals being 418,881 tons in 1920 and 397,513 tons in 1919; 1918 closed with 432,551 tons, reckoned as sulphate. In 1920, 40,207 tons were still produced in concentrated ammonia liquor, the demand for which is diminishing whilst dry neutral ammonium sulphate is more in demand.

The oxidation of ammoniacal liquor by air, a problem which has occupied the inspectors during the past twenty years, has not advanced much. The primary object was to convert the ammonium sulphide into thiosulphate so as to lessen the burden of the oxide purifiers; later the reduction of the amount of volatile cyanide in the liquors and indirectly in the crude gas entering the purifiers became another chief object of these experiments. Little has been achieved, but in view of the importance of the problem further particulars are given. Details are also published of the continued experiments on the use of burnt iron oxide and wood charcoal as catalysts in purifiers, especially in works in which the direct ammonia process had been adopted. The burnt oxide—which is essentially Fe_2O_3 (67 per cent.) with silica, alumina, titanium oxide and soda as chief impurities—answers well as catalyst as long as it is fresh, but falls off in efficiency. The impurities act apparently as promoters; the product is chiefly free sulphur, only a small amount of sulphur oxidation products being found. Wood charcoal, on the other hand, favours the production of acid products, little sulphur being liberated. Large-scale experiments will be required to solve the main problem.

Many complaints are reported to have been made with regard to chlorine and organic chlorination works; in the latter unpleasant odours may arise, and the chlorine tarnishes brass, among other things. The chlorine used is mostly liquid and is produced electrolytically; the numbers of works during the last three years were 32, 25, 33. Muriatic acid vapours may escape from salt works, from muriatic acid (not alkali) works, and from tin-plate flux works. The tin scruff from the latter may contain as much as 20 per cent. of zinc chloride, though the average is near 10 per cent., which should be removed before the scruff passes into the furnace. Something can be done by washing the scruff; Mr. Bailey also found that the scruff, if plunged hot from the tinning pot into cold water disintegrated and gave off most of its chloride; Mr. Clegg, of Cardiff, recommends wet grinding of the scruff.

In the 372 tar works, now open (375 in 1919), pitch stocks have accumulated, and the pitch fumes, arising when the pitch is run too hot into the bags, gave very unpleasant vapours. The tar distilled amounted, in tons of 190 gallons, to 1,450,535 tons in gas and coke-oven works and to 117,788 tons in other works, while the pitch produced in the same two kinds of works amounted to 677,295 tons and 63,468 tons. By providing an extra manhole for the tar still, Mr. C. W. Walker, of the Carnbroe Chemical Company, Scotland, has rendered the cleaning of tar stills much safer. It is noteworthy that only tar distillation falls under the Alkali Act.

In the chemical manure works, the number of which, 141, has hardly changed during recent years, the increase in the number of mechanical dens and a general supersession of manual labour calls for mention. The imports of guano and of sodium nitrate, practically nil in 1918, were last year up to 12,740 tons and to 147,477 tons respectively, and the import of mineral phosphates, 523,350 tons, had also risen. The works, both in England and Scotland, gave the inspectors some trouble.

There is no special mention in the Report of picric acid works, now reduced to 5 (15 in 1919). An appendix deals with the estimation of soot and the free acid in it, a problem of difficulty and of importance for atmospheric pollution.

NOTES.

The Science Museum.

From the report to the Board of Education of the Advisory Council for the Science Museum at South Kensington, it appears that there is still a serious lack of accommodation there, although part of the western galleries which had been devoted to other purposes during the war have now been restored to the Museum authorities. One gallery of the new buildings has, however, been brought into use and has made it possible to bring together and exhibit adequately the aeronautical collection. In consequence of the impossibility under present conditions of finding room for all the exhibits available several collections have been withdrawn from the public galleries and placed in rooms where they can be inspected by those specially interested in them, on making due application, and it is proposed in this way to find room, turn and turn about, for a full display of particular collections. The most noteworthy addition made to the Museum during the year was a Newcomen pumping engine constructed in 1791 by Thompson of Chesterfield, and which, it is stated, continued to work at Pentrich colliery, near Derby, till 1915. Another early engine has been presented to the Museum by the Salt Union. The galleries are, it appears, proving increasingly popular, and on certain Bank Holidays the crush has been so great that it has been necessary to suspend admission and to bring the emergency exits into use.

The South-West Midlands Electricity District.

A scheme for the supply of electric energy in the South-West Midlands Electricity District is jointly being submitted to the Electricity Commissioners by the Birmingham Corporation and the Shropshire, Worcestershire and Staffordshire Electric Power Company. As these two authorities supply between them 98 per cent of the electricity generated by authorised undertakers in the district, the scheme should obtain very favourable consideration. It is proposed that these two bodies should share the district between them and, while there would be no fusion of financial interests, a joint advisory committee would be appointed to deal with technical matters. This proposed scheme is intended as an alternative to the formation of a Joint Electricity Authority, and although there may very possibly be objection to it from some of the municipal bodies whose area is covered, it appears to afford a simple solution to the electricity supply problem in the area concerned. In view of the poor prospects of the new Electricity Bill dealing with the financing of Joint Authorities, any scheme carrying its own finance should be specially welcome. The South-West Midlands District, as provisionally determined by the Electricity Commissioners, covers parts of Shropshire, Staffordshire, Warwickshire and Worcestershire. It includes Birmingham in its north-east corner and extends southward to Evesham and Malvern and westward beyond Ludlow. The scheme proposes, briefly, that the Birmingham Corporation shall be responsible for electrical development in the City of Birmingham and that part of the area lying in Warwickshire and that the power company shall deal with the remainder. The Midland Power Company and the Leicestershire and Warwickshire Power Company are affected by some of the detail proposals, and these bodies will no doubt be heard in connection with the matter. The technical proposals are for ultimate supply mainly from the new Nechells station of the Birmingham Corporation and a projected 300,000 kw. station at Hams Hall, to the east of the city, also to be built by the corporation. The company would build a 105,000-kw. station at Stourport, on the Severn. Overhead transmission at 66,000 volts is proposed for the longer distance transmissions.

Electrically-Propelled Battleships.

The latest super-dreadnought of the United States Navy, the Maryland, has recently completed her preliminary trials, and is expected to be put through her official trials in November. The Maryland is the third in order of completion of the United States' electrically-propelled battleships. She was built by the Newport News Shipbuilding and Dry Dock Company and the electrical equipment was designed and manufactured by the General Electric Company, of Schenectady. The ship has a displacement of 32,600 tons and is 624 ft. long, with a beam of 97½ ft. She has a full speed of 21 knots, with a radius of 10,000 miles at cruising speed. Her main propulsion machinery consists of two Curtis turbine sets each developing 11,000 kw. at 2,030 r.p.m. These supply four 7,000-h.p. induction motors running at 170 r.p.m. and directly connected to four propellers. The motors are 12 ft. in diameter and weigh 62 tons. Either of the generating sets is capable of driving the ship at 17 knots. Steam is supplied by eight oil-fired boilers and the oil tank capacity is 1,392,200 gallons. The main armament consists of eight 16-in. guns and the secondary battery of fourteen 5-in. guns, four 3-in. anti-aircraft guns, a 3-in. landing gun, six 0·30 calibre machine guns and two 21-in. underwater torpedo tubes. Electrical appliances are used extensively throughout the ship, and auxiliary generating plant consists of six 300-kw. turbo sets. The preliminary trials of the Maryland passed off very successfully. They included a 33-hours' continuous sea trial in which the ship was put through severe and complicated manœuvres. Four more battleships of the Maryland type are to be completed this summer and, in addition, there are in progress for the United States Navy, six 43,000-ton, 60,000-h.p. battleships, and six 180,000-h.p. battle cruisers. These will all be electrically driven ships, and the machinery for several of them is now progressing under the direction of Mr. W. L. R. Emmet of the General Electric Company, whose successful work in the direction of electric propulsion is well known.

The North London Circular Road.

On Monday last, under the guidance of Mr. A. Dryland, engineer and surveyor to the Middlesex County Council, an inspection was made by a party of engineers of a section of the North Circular Road being constructed with the object of relieving traffic congestion in London itself. This road takes off the Great West Road at Chiswick, passes through Ealing, Park Royal, Willesden, Welsh Harp, Finchley, and Edmonton. It was a section at Willesden which was visited on Monday. The total length of the road in Middlesex is 12½ miles, of which 7½ are entirely new. The road is 100 ft. wide between fences, 16 ft. on either side being reserved for pedestrians, and a centre 20-ft. width for high-speed tramway track laid on sleepers, or a special track for heavy vehicles. The balance of 24 ft. on either side is reserved for ordinary wheeled traffic. One of these strips is now being constructed, and at the point visited is being laid down with Walker-Weston reinforcement. This system of reinforcement has been described and illustrated in ENGINEERING (vol. cxi, page 169). In this instance it is made up in sections 5 in. deep by 24 ft. by 6½ ft. The reinforcement works out at about 10 lb. per square yard and the price in this case is 3s. 8d. per square foot inclusive of laying and laps. The concrete is being laid, as Mr. Dryland stated at the Institution of Civil Engineers Conference, to such levels that an additional surfacing coat may be superimposed on it should that prove necessary. On the section visited the road is being carried across former sewage beds and the concrete slab laid is 8 in. thick. Of this the lower 5 in. are of 5 : 2½ : 1, concrete, and the

top 3 in. of 3 : 1 : 1 concrete. The material is handled by a Lakewood 21 cub. ft. concrete mixer, operated by one man and turning out about a 14-cub. ft. batch every 2 minutes. The laid concrete is levelled and consolidated by a petrol-driven tamper, giving a 3-ton blow. This machine is fitted with a screeding beam, and runs on rails on either side of the road laid to the required level. The concrete is being kept covered for three weeks with soil which is kept moist. It will be tarred and gritted before being put into commission. No expansion joints are provided in the carriageway. The labour is unskilled and mostly unused to navvy work, and in order to spread the relief over as many families as possible the gangs are frequently being changed. Costs are, therefore, not comparable with ordinary working, but, including allowance to cover plant, supervision, &c., the rate according to Mr. Dryland, is working out at 23*s.* 10*d.* per superficial yard, with ballast at 18*s.* per ton and cement at 90*s.* per ton.

THE NATIONAL PHYSICAL LABORATORY.

(*Continued from page* 159.)

Metallurgy and Metallurgical Chemistry. (Superintendent Dr. W. Rosenhain, F.R.S.; senior assistants, Messrs. J. Murdock, S. L. Archbutt Guy Barr, D. Hanson.)—The staff has been weakened by the resignation of Mr. E. A. Coad Pryor and others. The additions to the equipment comprise a pneumatic power hammer (from the laboratory of the late Professor Huntington, King's College), of a horizontal milling machine for the preparation of test pieces from alloy sheet metal, and of a 15 k.v.a. transformer. The Morgan crucible (carbon-resistance furnace), which we have already described, is particularly used for the study of aluminium alloys in air and various gases; the furnace was presented to the Laboratory.

Light Alloys. (Messrs. Archbutt, D. Hanson, Miss M. L. V. Gayler, Miss K. Bingham.)—The eleventh report of the Alloys Research Committee of the Institution of Mechanical Engineers, which will be published at an early date, will deal with the further important work done under the auspices of the Institution just named and of the Advisory Committee for Aeronautics. Ternary alloys of aluminium with copper and zinc and with magnesium and silicon, have been sufficiently studied to enable models to be constructed, covering, at any rate, certain corners of the equilibrium diagrams. In the magnesium-silicon alloys the compound Mg_2Si seems to play a particular part in the age-hardening process of alloys like duralumin. This compound, though not yet isolated, appears in small crystals of a blue iridescence in specimens etched with nitric acid, and its existence seems to be sufficiently well established from the equilibrium model, which is based upon thousands of experiments—numbers of experiments which would have been impossible, we might add, without the aid of the Rosenhain chronograph and the Hanson-Haughton thermostat. As regards hardening subsequent to quenching, either directly or after an ageing process, the hardening is, according to Dr. Rosenhain, the result of the temporary retention in solid solution of a substance which, either in the cooling process itself, or subsequently during ageing and tempering, tends to separate out in the form of a very minute secondary constituent in a finely dispersed condition. This seems to apply generally, to carbon steels as well as to aluminium alloys. The dissolved material may be any compound which is more soluble at its melting-point than at lower temperature.

Cast and Wrought Alloys.—By heat treatment an aluminium cast alloy containing 4 per cent. of copper, as well as 2 per cent. of nickel and 1½ per cent. of magnesium, the rest being aluminium, has been transformed into a material reaching a tensile strength of from 17 tons to 19 tons per square inch in chilled cast bars, 1 in. in diameter; such an alloy, of a density 2·85, will admit of many applications for aircraft and automobiles. Attempts to provide these light alloys with a hard surface, such as case-hardening gives to steel, have so far not been successful; inward diffusion of copper has been tried among other things. The 4 : 2 : 1½ alloy can also be wrought and is further interesting on account of its high power of resisting corrosion; similar alloys have hence been studied, the percentages of copper and nickel being raised to 7 and 6 respectively, but so far without satisfactory results. Other alloys admitting of forging are the 3/20 (aluminium with 3 per cent. of copper and 20 per cent. of zinc) and the "high tensile"; considerable progress has been made in their manufacture. In connection with the standardisation of these alloys, Mr. C. B. Marryat, of the department, has constructed a simple bend-testing machine, in which the reverse bending of the strip of sheet metal takes place accurately along the same line so that no region of double curvature can form, a feature difficult to avoid in other machines. Mr. Marryat overcomes the defect by the use of a rocker frame carrying two interchangeable pins, whose diameter and distance apart can be altered to meet the requirements of the thickness of the sheet, the quality of the material, &c. Each of these pins acts alternately as the "radius bar," about which the frame rocks and the strip is bent, and as the "bending bar," which serves to press the strip under test against and around the radius bar. The machine is intended for testing strips of sheet metal (steel or non-ferrous metal) by reverse bending through 90 deg. These alternating bending tests—we described another machine designed by Mr. Jakeman for the same purpose last year—are not considered characteristic for the hard aluminium alloys, however; in their case it is found more satisfactory to rely on a single bend and to measure the angle through which the specimen can be bent around a given radius.

Another series of measurements, made by Mr. J. D. Grogan, concerns what used to be called the yield-point, but which is now called the "proof-load" in the case of alloys which do not show any definite yield-point on the testing machine. The proof load is defined as the stress which, after removal of the stress, does not produce an elongation of more than 0·5 per cent. on a gauge length usually of 2 in. With respect to the riveting of aluminium alloys it was generally considered that rivets of duralumin were not suitable, for small objects, at any rate, and the rivets were hence made of pure aluminium or of alloys containing very small amounts of a hardening constituent; that precaution would appear to be unnecessary. There is one more point to be mentioned in connection with the ageing of duralumin and the high-tensile and 4/2/1½ alloys. They may warp after quenching, but the volume changes seem to be very small, hardly exceeding the limits of experimental errors; the question is further being investigated.

Zinc Alloys. Season Cracking. Ohmal.—The work of Dr. Haughton and Miss Bingham on Zinc and its Alloys has already been brought before the Institute of Metals. Season Cracking, on which much original work has been done at Teddington, was recently discussed at Storey's Gate.*

The fine "transparencies" exhibited on the inspection day by Dr. Rosenhain, brought out many of the striking features of the various alloys. The specimens of "Ohmal," the substitute for manganin made entirely in the Laboratory, testified to the difficulties of the manufacture of this alloy, which turns brittle and unreliable when the thermal and mechanical treatment allow it to assume a coarse radial, instead of a fine-grain, structure.

Iron and Steel.—A research into the temperature of incipient fusion and the final solidification of iron-carbon alloys was started by Mr. Asahara, a Japanese metallurgist and temporary worker in the Laboratory, and is being continued by Mr. F. S. Tritton. Failures of alloy steels (Ni and Ni-Cr) in aeronautical machinery have been investigated by Mr. Hanson and Miss H. Fry; they find that martensite forms a micro-constituent also of these alloys. One of the researches which Dr. Rosenhain has recently undertaken with Miss Gayler is the determination of the quantity of heat generated during the mechanical deformation of a metal; Mr. Sinnett is said to be studying the same problem at King's College. Considerable progress has been made with the standardised steel samples which are now ready for issue in their glass bottles.

Optical Glass.—The problem of pot attack* is further being studied by Miss A. B. Taylor in large furnaces, in which the temperature distribution is more homogeneous than in small furnaces and the convection currents therefore of less importance. One of the other chief problems is that of the "working range" and viscosity of glasses for drawn tubes and for bulbs.

Aeronautical Chemistry. Dopes, Viscosity, Fabrics, Gas Density.—The search for suitable solvents for cellulose acetate is being continued. The ordinary solutions do not contain more than 8 per cent. of the cellulose acetate, more concentrated solutions being too viscous as dopes; hence a great deal of solvent is wasted, and the films are less strong and permanent than they would be if more concentrated solutions could be applied. Another problem still under investigation is the connection between the viscosity and other properties and the constitution of the several cellulose acetates, which seem to form different molecular complexes in different solvents such as acetone and chloroform. In determining the viscosity of viscous materials, glycerol (glycerin), is commonly used as standard, and it is assumed that the viscosity of the glycerol changes with its density; the latter depends mainly upon the amount of water present in the glycerol (which is hygroscopic), but there are certain impurities in glycerol which also affect its viscosity, and these influences are not yet understood. As regards the permeability of fabrics to gases it is now recognised that the escape of hydrogen from a balloon is perhaps less important than the inrush of air into it. In this connection Dr. Guy Barr is investigating the reliability of gas-efflux meters of the Bunsen type.

In these meters the gas is allowed to escape through a small orifice, and the time which a certain volume of gas will require to escape is assumed to be proportional to the square root of the density of the gas. Two types of instruments have been based upon this principle. In displacement meters the time is measured which is taken by the liquid (water or mercury) in the gasholder to displace a definite volume of gas at atmospheric pressure; in the expansion meters the gas is allowed to expand from high pressure to low pressure. Both types have been used, in America, especially for determining the density of natural gas, from which conclusions as to the constitution of the gas can be drawn; but the results were found to be discordant and doubtful by as much as 40 per cent. in some cases. Hence Messrs. E. Buckingham and D. Edwards, of the Bureau of Standards, investigated the Efflux of Gases from small Orifices† and they found that with certain precautions an accuracy of 2 per cent. was possible. Some points require further elucidation, however, and Dr. Guy Barr is investigating the problem.

Heat Division. (Dr. G. W. C. Kaye, Dr. E. Griffiths, Messrs. F. H. Schofield and A. H. Davis.)—The amount of test work carried out was about normal, not reckoning 150 lamps designed for the optical pyrometer of the disappearing-filament type and 130 nickel resistances for low-temperature work. For the Indian Survey, the Laboratory tested (and partly designed) a set of platinum resistance thermometers, to measure small temperature differences in the lower atmosphere.

Cold Storage Research. Thermal Conductivity of Insulating Materials. Hot-Wire Anemometer.—The main research work has been conducted for the Insulation Committee of the Food Investigation Board. The refrigerating plant for this research, mentioned in our previous report, has been presented to the Laboratory by Messrs. J. and E. Hall, of Dartford; the plant, which was formerly on loan, comprises an ammonia compressor and brine tanks. In the study of the thermal properties of granular materials convection currents circulating through the material are found to play an important part, and the heat-transmission coefficient through a wall of such material may change by 10 per cent. with the orientation, vertical or horizontal, of the wall. The hot-wire anemometer,

* See ENGINEERING, April 8 and 15 last, pages 429 and 443, "The Failure of Metals."

* See ENGINEERING, June 6, 1919, page 725.

† Scientific Papers, U.S. Bureau of Standards, No. 350, 1920.

used in these determinations, is essentially a Wheatstone bridge, three arms of which are composed of stout constantan wires, while the fourth arm is a thin platinum wire which serves alternately as resistance thermometer and as anemometer. With a very small current flowing through the bridge circuit, the temperature of the air, in which the platinum wire is suspended, is obtained by balancing the resistance of the platinum when in temperature equilibrium with the air stream. When the velocity of the air is to be determined, a definite resistance is thrown into the third arm of the bridge, and the balance is restored by increasing the current until the heating of the platinum wire raises the resistance to the point desired for restoring the balance. From the reading of the amperemeter the energy consumed in the hot wire is deduced, and hence the velocity of the air stream. When the velocity is varying, the use of a "null" instrument is somewhat troublesome, and the instrument has therefore been made direct reading. For each temperature there is an appropriate heating current for which the indicator gives directly the mass velocity of the air stream passing the wire; for a temperature range from 17 deg. to 170 deg. C. only 7 per cent. variation in the current is required. The indications are sufficiently correct for most practical purposes. The calibration of the anemometer in very slow air currents was difficult; a vertical wind channel was constructed, the diameter tapering down from 15 in. in the main portion to a Venturi neck of 2·6 in.; a Pitot tube was inserted in the neck where the velocity was sufficiently great for measurements. The velocity in the large channel was then calculated from this velocity and the ratio of the areas of cross-section.

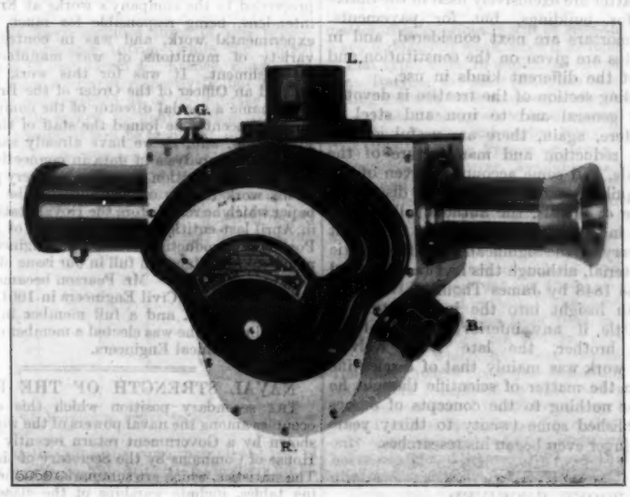

FIG. 12. PORTABLE OPTICAL PYROMETER.

Specific Heat of Insulating Materials.—To the variety of materials tested, cork, charcoal, slag wool, diatomaceous earth, &c., porous rubber has quite recently been added; this material, which is slightly vulcanised and has a pinkish colour, is so light, apparently owing to impregnation with some gas, that a block of 1 cub. ft. might serve as a ball for play. For the specific heat determinations of these materials the method of mixture is not suitable, because prolonged exposure to a temperature nearly of boiling water would drive off the moisture so that the material is not really tested in its natural state. For other considerations it is necessary, moreover, to reduce the materials when fibrous or not already finely-granulated to a state of fine subdivision. The apparatus adopted is an aluminium drum, of 4·3 litres volume, very light and of low heat capacity, which is charged with the material and turned about its horizontal axis once every 2 seconds. Inside the drum is a heating coil, of nichrome or platinum, which is kept stationary; helical fins are so fixed to the inner wall of the drum that the material it contains is carried up and dropped through the wire or tape of the coil and at the same time mixed longitudinally; to hasten the mixing, the whole apparatus is swung about an axis at right angles to the axis of rotation. The drum is itself placed inside a heating jacket, consisting of a co-axial cylindrical vessel wound with a heating coil of asbestos-covered copper wire. By this arrangement the correction for radiation from the external surface of the drum is reduced to a minimum. When the temperature has risen in the drum calorimeter to a steady value, say from 16 deg. to 30 deg. C., in 15 minutes or less, the specific heat of the material under test is deduced from the current consumption. In this way Dr. Griffiths and Mr. E. R. Strand found the following moisture contents and specific heats at a mean temperature of 25 deg.:—

Material.	Moisture. Per cent.	Specific Heat.
Charcoal	6·89	$0·29_9$
Slagwool	0·02	$0·17_1$
Diatomaceous Earth...	2·09	$0·23_2$
Baked Cork (slab)	—	$0·43_1$
Granulated Cork	3·45	$0·43_8$

Heat Losses from Hot Surfaces. (Dr. Griffiths.)—For the British Portland Cement Research Association, Dr. Griffiths is determining the coefficients required for calculating the heat losses from the surfaces of rotary kilns. These kilns are steel cylinders, about 200 ft. long, diameter 6 ft. to 10 ft., rotating about their longitudinal axes at peripheral speeds from 15 ft. to 30 ft. per minute, the surface temperature rising to 480 deg. C. Experiments were made with cylinders of 9 in. diameter, 4 ft. long, electrically heated. Platinum or nichrome coils being too expensive for the dissipation of a heating current of about 20 kw., strips of steel were wound on a mandrel and sprung into contact with the internal cylinder wall but insulated from it by a thin sheet of micanite. There was some shifting of the turns and arcing, however, in the course of time, and the spiral was finally replaced by a long carbon tube supported along the axis of the cylinder by "spiders" and suitably insulated. To avoid heat conduction losses along the shaft and the brush gear the cylinder was suspended by insulated hooks. The thermocouples were inserted into holes drilled into the cylinder surface and filled with alloy.

By means of indicating points in a vertical section of the cylinder as on a compass card, the temperature distribution observed was, for instance, S.W. and S.E., 226 deg. and 223 deg. C.; N.W. and N.E., 242 deg. and 240 deg. C. The temperature was lower on the lower than on the upper surface owing to convection currents. These currents were measured at different distances from the cylinder; the curves obtained show the strong influences of draughts which can hardly be avoided even when working in special rooms. In these determinations use is made of the combined thermometer and anemometer of Dr. Griffiths. The radiation losses from the cylinder surface are determined with the aid of a total radiation pyrometer which gives the emissivity, *i.e.*, the ratio of the heat lost from the actual surface to that lost by a black body. The emissivity of partly oxidised iron is about 0·8, varying with the degree of oxidation of the iron between 0·79 and 0·89. The convection loss (including heat conduction through the air) is found as the difference between the total loss and the radiation loss.

The losses depend upon the shape and size of the object. The losses increase in general as the curvature increases and the size decreases, but for bodies of fairly large dimensions, say, 25 cm., size and curvature make little difference; yet large bodies seem to lose more heat than they should theoretically. For a vertical plate the loss is about the mean between the losses observed downward and upward when the plate is placed horizontally, and the influence of the height of a vertical plate may be neglected. The influence of the rotation is also small at the low kiln speed (about 1 r.p.m.) With the various restrictions pointed out the law of similitude can be applied, and conclusions can be drawn from experiments on reduced scale; but the problems are complex and require further investigation.

Distance Reading of Dew Points.—Several new dew-point indicators were shown on the inspection day. In one of them a bright copper disc is mounted in an ebonite block; at the back of the disc are the connections for the cooling brine pipe; when the dew-point is reached the disc turns dim. In another device the cooled surface is a small plane mirror of untarnishing steel which is illuminated by a small lamp; the amount of heat reflected by the mirror diminishes when the dew covers the mirror; the heat rays are concentrated by a second concave mirror on a small thermocouple in circuit with a needle which swings round when condensation sets in.

Portable Optical Pyrometer.—The simple portable pyrometer of Dr. Griffiths illustrated in the photograph, Fig. 12, is of the disappearing-filament type which we noticed in our report on the exhibits at the May Soirée of the Royal Society.* An image of the hot object is superimposed upon the filament of the pyrometer lamp; the current through the lamp is varied until the brightness of the filament matches the brightness of the image of the hot object, which is looked at through the telescope. The large instrument which we mentioned in May is now being calibrated. In the portable type shown in our illustration the telescope variable resistance R, and current meter are all united; the lamp fits into the holder L, the battery (4 volts) terminals are at B, and an absorption glass A G can be interposed in the path of the light in order to pass from medium temperature to high temperature. The two scales marked read temperatures directly, from 700 deg. up to 1,400 deg. C., and from 1,000 deg. to 2,500 deg. C. The lamp is never run at high intensity and should have a good life. The compact instrument is about 6 in. long and weighs, without battery, 2 lb. An accuracy of 10 deg. C. is realised, which is satisfactory for a small portable pyrometer.

Electric Heating.—A report on Thermal Characteristics of Electric Ovens and Hot Plates was brought before the Institution of Electrical Engineers last January. The research had been conducted by Dr. Griffiths and Mr. Schofield on the instigation of the British Engineering Standards Association. The construction of these appliances should be adapted to the object in view, of course; for grilling the resistance should be bare, for prolonged heating the plates and ovens should be well lagged. Various commercial appliances were tested, but the paper gives information on the method of conducting efficiency tests rather than on the appliances.

Coefficients of Expansion at High Temperature. Quartz.—The apparatus of Dr. E. Griffiths for determining the expansion coefficients of metals at high temperatures were mentioned by us last year. In this connection an apparatus was also designed for determining the temperature coefficient of the Young modulus of fused quartz. Measurements were made, at room temperature and at 500 deg. C., on a quartz tube, by the method of the loaded beam, and it was found that the quartz was less flexible

* See ENGINEERING, May 13, page 592.

hot than the cold quartz, differing in this respect and also as regards the rigidity modulus from metals. A loaded quartz fibre, sagging under the load, straightens out by upward movement when the fibre is heated.

(To be continued.)

LITERATURE.

Johnson's Materials of Construction. Fifth edition, re-written by M. O. WHITNEY and JAMES ASON. New York: John Wiley and Sons; London: Messrs. Chapman and Hall. [Price 30*s.* net.]

THE fifth edition of this important work has been practically entirely re-written and brought up to date, and in its new form constitutes an extremely valuable reference book. The two authors supplement each other, one being the Associate Professor of Mechanics at Wisconsin University and the other a professional metallurgist. In their new preface the authors quote with approval from the preface to the first edition, Professor Johnson's dicta as to the requisites for the rational design of a structure. These were stated to include a knowledge of the external forces acting, the resultant internal stresses and the mechanical properties of the material employed. An English engineer would be inclined to add to this list the additional requirement of experience with the material as employed in structures analogous to that about to be constructed. Lacking this, the working stresses adopted must always be more or less tentative and provisional, since there is no one theory of the relationship between working stress and the factor of safety which is universally applicable.

The opening chapter of the treatise is devoted to a discussion of the behaviour of materials under different types of stress. The section dealing with the strength of struts is perhaps the least satisfactory, the illuminative investigations of Claxton Fidler being totally ignored. In short, no attention is directed to the fact that the strength of struts as experimentally determined if plotted diagrammatically against the ratio of the length to the least radius of gyration is represented by an area and not by a curve. No doubt if it was the intention of the authors merely to give reasonably safe formula for column resistance this end is attained, but the essential characteristics of the problem are far from adequately elucidated.

With respect to the strength of curved beams, the treatment appears somewhat inadequate owing to the total ignoration of the radial stresses. It is probably true that in practice the failure of shearing machine frames and the like is more commonly due to the radial stresses than to the longitudinal stresses. It may be noted that for the case of a solid hook of rectangular section, the theory of elasticity gives a complete solution, as shown in our issue of September 5, 1913 (page 307). In practice, the stress distribution over the cross-section of a hook or similar curved beam is not linear, as it is in the case of a straight beam, but is sensibly hyperbolic, as was pointed out in the article already cited. The formula given by the authors is equivalent to this hyperbolic law, and is very accurate save when the inner radius of curvature is a very small fraction of the outer radius of the hook. As already stated, however, the authors ignore the radial stresses, which are often very important in the case of hollow or I-beam sections. In this theory it may further be noted that the authors adhere to the old view dating from the ante-aeroplane period, in which it was considered that if a strut was subjected both to bending and to a thrust the stress was equal to the sum of the stresses, due to each type of loading if applied separately. This is certainly not the case, as this constitutes one of the few instances in theoretical mechanics in which the principle of the superposition of stresses fails. In fact, the stresses are no longer linear functions of the loads.

In the following chapter machines and appliances for mechanical tests are described. Naturally American designs predominate, and, indeed, for ordinary straightforward tensile and compressive tests the Emery machines stand in a class apart, whilst so far as capacity goes there is nothing we believe on this side of the Atlantic to match the 10,000,000 lb. compression testing machines erected at the Pittaburg Laboratory of the United States Bureau of Standards. These very large machines, however, have but a limited field, though in that they stand alone. For ordinary work they are too expensive and cumbrous. Most testing work is executed less with a view to determining the strength and elastic constants of a material than to secure the uniformity of a material of which the general properties are already well known. The Brinell tester and the Shore sclerometer are very serviceable in this regard, and are fully described by the authors. Notched bar tests also receive mention, but the Sankey bend tester is unnoticed, although there is good reason for believing that this machine is one of the most satisfactory for determining the structural value of a material.

A large amount of space is devoted to the properties of timber, which have been very thoroughly investigated in the United States. This section of the volume will be read with great profit, and be very valuable for reference purposes. The structure of the different kinds of wood are described at length, as well as the mechanical properties as determined in the testing machine. The next section of the book is devoted to a discussion of the materials used in house building, special attention being given to the manufacture and testing of clay products. The latter are exclusively used in the States not merely for buildings, but for pavements. Cements and mortars are next considered, and in each case notes are given on the constitution and preparation of the different kinds in use.

The concluding section of the treatise is devoted to metals in general and to iron and steel in particular. Here, again, there are useful general notes on the reduction and manufacture of the different metals, and some account is given of the iron-carbon equilibrium diagram. In the discussion on the fatigue of metals, the authors follow Professor Unwin in giving to Bauschinger the credit for the discovery of the significance of the elastic range of a material, although this had been pointed out as early as 1848 by James Thomson, who was gifted with an insight into the inner nature of phenomena little if any inferior to that of his better-known brother, the late Lord Kelvin. Bauschinger's work was mainly that of a scientific hodman, as in the matter of scientific thought he added little or nothing to the concepts of James Thomson, published some twenty to thirty years before Bauschinger even began his researches.

BOOKS RECEIVED.

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United States Geological Survey. Mineral Resources of the United States. I: 29. *Lead in* 1918 *(General Report).* By C. E. SIEBENTHAL. II: 10. *Sand and Gravel in* 1919. By R. W. STONE. Washington: Government Printing Office.

United States Coast and Geodetic Survey. Annual Report of the Director to the Secretary of Commerce for the Fiscal Year ended June 30, 1920. Washington: Government Printing Office.

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Kelley's Directory of Merchants, Manufacturers and Shippers of the World, 1921. Vols. I and II. London: Kelly's Directories, Limited. [Price 64*s.* net.]

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THE LATE MR. R. J. A. PEARSON, O.B.E., M.Sc.

WE regret to have to announce the death, on Monday last, of Mr. Robert John Addison Pearson, O.B.E., M.Sc., who was on the staff of the Engineering Employers' Federation, and who did valuable work in connection, principally, with the collation of data affecting costs of production and other statistics essential to the settlement of agreements between employers and workers. Mr. Pearson was in his forty-fifth year, having been born on February 10, 1877. He was educated at the Hall Gate Schools, Doncaster, and proceeded thence for his engineering training, first, under Mr. Stirling and, later, under Mr. Ivatt, at the Doncaster Works of the Great Northern Railway. Here he continued until 1898, when he took up engineering studies at the Yorkshire College, Leeds, ultimately taking his B.Sc., with honours in engineering, at the Victoria College, Manchester University. During the summer vacation of 1898 he was with Messrs. Jenkins and Co., engineers, Retford, being in charge of the erection of a coke conveyor at the Gas Works, Bury, Lancashire. On the completion of his college course, he joined the staff of Messrs. Vickers, at Barrow-in-Furness, as a works draughtsman, and was engaged, principally, in the design of labour-economising tools and the arrangement of shop extensions. In 1903 he became assistant manager to the Vickers Shot and Shell Department at Barrow-in-Furness, while later he was in charge of the erection, on board warships, of gun mountings. In 1910 he proceeded to the company's works at Erith, as superintendent, being responsible for much research and experimental work, and was in control of a great variety of munitions of war manufacture at this establishment. It was for this work that he was created an Officer of the Order of the British Empire. He became a special director of the company in June, 1919. Recently he joined the staff of the Employers' Federation, and, as we have already said, did much towards the analysis of data in connection with costs and works production generally. A very good example of his work in this connection is to be found in the paper which he read before the Royal Statistical Society in April last entitled "A Comparison of Pre-War and Post-War Production Costs in Engineering." This paper we reproduced in full in our issue of April 29 last (vol. cxi, page 537). Mr. Pearson became a student of the Institution of Civil Engineers in 1901, an associate member in 1904, and a full member in 1919, about which time also he was elected a member of the Institution of Mechanical Engineers.

NAVAL STRENGTH OF THE POWERS.

THE secondary position which this country now occupies among the naval powers of the world, is clearly shown by a Government return recently made to the House of Commons by the Secretary of the Admiralty. The statistics, which are summarised in the accompanying tables, include warships of the classes indicated, which have been launched since the end of 1900 and also refer to vessels under construction. In the matter of capital ships it will be seen that the first place is now held by the United States, which country has 36 battleships built and 11 battleships and 6 battle cruisers under construction, while Great Britain has 23 battleships and 8 battle cruisers, but is not actually building any capital ships at the present time. Japan, which now takes third place as a naval power, is building 3 battleships and 2 battle cruisers and even Russia is believed to have 4 ships of the latter class in hand.

With regard to the British capital ships, it should be mentioned that the latest battleships are those of the Royal-Sovereign class, including Royal Sovereign, Royal Oak, Revenge, Resolution and Ramillies, all of which were completed in 1916, except the Ramillies, which was finished in the following year. None of these vessels has therefore been designed since the lessons of the war have been assimilated. British battle cruisers, excepting the Hood, Renown and Repulse, were all completed before the war, and, of the three exceptions, only the first-mentioned is sufficiently modern to include design features arising from war experience. The United States, on the other hand, has completed the battleships Mississipi, New Mexico, Idaho and Tennessee since 1917, and the 11 now building will be completed before the end of next year. Six of the latter, viz., those of the South-Dakota class, are of 43,200 tons displacement and of 60,000 h.p., and each carries twelve 16 in. guns, sixteen 6 in. guns, four 14 pr. anti-aircraft guns, and two 21 in. submerged torpedo tubes. The battle cruisers now building in the United States are of the Lexington class and are expected to be completed in 1924. They are of about the same displacement as the battleships, viz., 43,500 tons, but the machinery, which is of the turbo-electric type, will be of 180,000 h.p. The armament is similar to that of the battleships, except that only eight 16 in. guns are carried and that there are four additional

torpedo tubes above water as well as two extra submerged tubes.

Of the battle cruisers building in Japan, no particulars are at present available, and all that is known of the Japanese battleships under construction is that one of them, the Mutsu, is of 33,800 tons displacement and 46,000 h.p. and that she will carry eight 16 in. guns, twenty 5·5 in. guns, four 12 pr. high-angle guns, and eight torpedo tubes. The completed warships include Fuso, Yamashiro, Ise, Hyuga and Nagato, all finished since the outbreak of war. The latest of these, the Nagato, which was only completed last year, carries the same armament as the Mutsu, and is also of the same horse-power and displacement.

Although Russia is nominally building four battle cruisers, two of which were launched in 1915 and the other two in 1917, the work on these vessels is not actually in progress. Their tonnage is given as 32,500 and their horse-power as 68,000, while the armament is stated to be twelve 14 in. guns, twenty-four 5·1 in. guns, and six submerged torpedo tubes. Whether these vessels will ever be completed is, perhaps, open to question considering the internal condition of the country, but, in any case, the vessels are outclassed by those of other powers above referred to. The point we wish to emphasise in connection with capital ships is that the position of Great Britain is relatively weaker than appears to be the case from a consideration of numbers only, owing to the fact that the vessels completed, or approaching completion, in the United States and Japan are of later design.

No country is now building the class of vessels known as armoured cruisers and first-class protected cruisers, but the British Navy includes three of this type—Courageous, Glorious and Antrim—while the United States possesses 15 and Japan 4. France, Russia and Italy have 10, 9 and 5 cruisers, respectively, but 2 of the Italian cruisers are regarded as of no military value. The position with regard to light cruisers is given in Table I, from which it will be seen that, of this class

TABLE I.—*Capital Ships and Light Cruisers.*

—	Battleships.		Battle-Cruisers.		Light Cruisers.	
	Built.	Building	Built.	Building	Built.	Building
Great Britain	23	—	8	—	51	10
United States	36	11	—	6	15	10
Japan ..	12	3	7	2	9	8
Italy ..	12*	—	—	—	10	—
France ..	11	—	—	—	5	6 (Projected).
Russia ..	13	1	—	4	1	8
Germany ..	8	—	—	—	8	—

* The Minister of Marine has power to remove 4 of these vessels from the list.

of vessel, Great Britain owns more than all the rest of the world put together. The British light cruisers building are three of an improved Birmingham class, three "D" class, two "E" class, and two other vessels. With regard to aircraft carriers the British Navy also maintains its foremost position, having four vessels of this type completed and two in hand. The completed aircraft carriers are Furious, Argus, Pegasus and Ark Royal, while those building are Hermes and Eagle. The United States and France possess one aircraft carrier each, and both these countries have another vessel of the same class in hand. Japan has no aircraft carriers at present, but the construction of one is under consideration.

With regard to smaller craft, the relative positions of the various naval powers can be seen from Table II, and the predominant position of the United States,

TABLE II.—*Small Craft.*

—	Flotilla Leaders.		Destroyers.		Submarines.	
	Built.	Building	Built.	Building	Built.	Building
Great Britain	16	2	185	6	89	8
United States			278	40	103	46
Japan ..		—	84	9	23	15
Italy ..	8	3	52	12	64	3
France ..	1	1	70	1	48	6
				(12 projected)		
Russia ..	—	—	98	21	36	22
Germany ..	—	—	16	12	—	—

both in the matter of destroyers and submarines, will at once be evident. The United States Navy includes 278 destroyers, of which 178 have been completed since the end of 1918. Of the 40 now under construction, nearly all are of 1,215 tons displacement, and of 27,000 h.p., while the armament is generally four 4 in. guns, one 14 pr. anti-aircraft gun, and four 21 in. triple torpedo tubes. Only six destroyers and two flotilla leaders are now building in Great Britain, the two flotilla leaders being Keppel and Rooke, both of 1,750 tons displacement and of 40,000 h.p. The armament of these vessels includes five 4·7 in. guns, one 3 in. gun, two 2 pr. guns and two triple torpedo tubes. The British destroyers under construction are Shikari, Thracian, Whitehall, Worcester, Wren, and Witch. The two first-mentioned are of 1,075 tons displacement and of 27,000 h.p., and both carry three 4 in. guns, one 2 pr. gun and two double torpedo tubes; the other four displace 1,325 tons and carry four 4·7 in. guns, two 2 pr. guns, and two triple torpedo tubes. The horse-powers of Whitehall, Worcester and Wren are 27,000, while that of Witch is 30,000.

Russia, it will be seen, takes third place with regard to destroyers, having 98 of these vessels completed and 21 in hand, while the Japanese Navy, which occupies the fourth place, includes 84 destroyers and is building nine in addition. The latter include six first-class and four second-class vessels, the former displacing 1,345 tons and having machinery of 38,500 h.p. The armament of the first-class destroyers is four 4·7 in. guns, two machine guns and six torpedo tubes; six exactly similar vessels have already been completed.

In connection with submarines, the extensive naval development of the United States will also be apparent from Table II. There are 46 submarines now building for the United States Navy, which already includes 103, and the new vessels will all be completed during this year or next. The majority of the existing vessels are also of late design, only 33 of them having been completed before 1918. The British Navy, as shown in the Table, includes 89 submarines and is building eight in addition. Of the vessels building, seven are of the "L" type and one is of the "K" type. In the matter of submarines it will be seen that the Japanese Navy is relatively weak, since it includes only 23 vessels of that type, while 15 additional submarines are building. Italy, on the other hand, has 64 submarines and is adding three to their number, while Russia is building 22, so that, if these were to be completed in a reasonable time, the Russian submarine Navy would be greater than that of either France or Japan. Very little information is, however, available as to the Russian Navy, and the figures given, both for vessels building and completed, are by no means reliable.

The condition of impotence to which the German navy has been reduced can be gathered from the tables, and to this we may add the information that the eight battleships it now includes, are all old designs completed between 1904 and 1908; no guns larger than 11 in. are mounted in them. The German light cruisers are even older, dating from 1899 to 1905, and their armament includes ten 4·1 in. guns in each case, except one, which has been completely disarmed. The most modern destroyers remaining in the German Navy were completed in 1913 and are of 555 tons displacement and of 15,000 h.p.; they carry two 4·4 in. guns, four machine guns and four torpedo tubes. The only other war vessels left to Germany are 16 torpedo boats, completed between 1907 and 1911 and at present disarmed.

Thus, what was in pre-war times the main incentive to naval construction in this country has, for the time being at all events, ceased to exist. Sea power is, however, still of vital importance to the integrity of a scattered empire such as ours, and the British Navy is to-day, no less than formerly, an essential instrument for the preservation of the peace of the world. Thus, although the necessity for numerical superiority may be less than it was, the need for the highest possible efficiency is even greater. For this reason, it is important for the public to realise the fact, above referred to, that, whereas the majority of the capital ships of the British Navy were designed before lessons learned in the war could be applied, some foreign powers have made, and are making, considerable use of the recent practical experience in naval warfare.

THE TWIN-SCREW MOTORSHIP "MALAYA."

THE twin-screw motorship Malaya, built by Messrs. Burmeister and Wain, Limited, Copenhagen, for the East Asiatic Company, Limited, also of Copenhagen, left that port on the 16th inst. on her maiden voyage for the Far East. She is a sister-ship to the motorship Afrika, which was handed over to the same company in March of last year, and has been built to Lloyd's class 100 A1 +, awning deck with freeboard, and her principal dimensions are the following:—

Length, overall	464 ft. 6 in.
Length between perpendiculars	445 ft.
Breadth on frames	60 ft.
Depth from awning deck ...	42 ft.
Depth from upper deck ...	33 ft. 3 in.
Depth from lower deck ...	23 ft. 3 in.
Draught loaded	32 ft.
Displacement	19,000 tons.
Deadweight	13,500 tons.
Gross tonnage	9,050 register.
Loading capacity—	
Grain	700,000 cub. ft.
Bales	640,000 cub. ft.
Water ballast...	1,664 tons.
Provision of oil	1,472 tons.
Radius of action	About 30,000 miles.

The propelling machinery consists of two main engines of the Burmeister and Wain standard, direct reversible, crosshead type, with forced lubrication. The cylinders are 740 mm. (29·134 in.) in diameter, the stroke being 1,150 mm. (45·275 in.). The engines can develop together 4,500 i.h.p., giving the ship when fully loaded a speed of 12 knots. The oil fuel consumption, on the basis of the results given by the sister-ship Afrika on her maiden voyage, is 14 tons per 24 hours. On the trial trip, common crude oil being used, the consumption was measured during 4 hours, during which time the engines developed an average of 4,585 i.h.p., the consumption being 135·3 grammes per indicated horse-power, corresponding to 14·6 tons per 24 hours. In this connection the builders state that with motorships consumption is always greater on trial trips than in actual service under normal conditions at sea, since on the trial trips, which are of comparatively short duration, the engines do not heat up and their working is economically not so good, this forming a contrast with what obtains with steamships and forming an advantage in favour of motorships. During the trial trip several runs were made over the measured mile, when an average speed of 13·1 knots was obtained. The ship was light, the draught forward was 7 ft. 5 in., and aft 15 ft. 9 in., the displacement being 6,180 tons. Manœuvring from full speed ahead to full speed astern was effected to the entire satisfaction of the shipping authorities on board to witness the trials.

The auxiliary machinery consists of three 100 e.h.p. Diesel dynamo sets, each coupled to a 66 kw. 220 volt dynamo, supplying current to the auxiliary engines in the engine room, to the steering engine, the windlass, winches and for lighting the ship. For lighting, the current is transformed down to 110 volts, by a rotary transformer. There are three cooling water pumps direct coupled to an electric motor.

The main engines are water-jacketted and the water circulation system is combined with a water cooler. In the case of ships having a deep draught, it may occur that in shallow water mud may be drawn in with the cooling water; the arrangement followed in the Malaya obviates this, and the engine room is always clean.

The circulating of the lubricating oil is effected by two sets of forced lubrication pumps, these being gear pumps, each coupled to an electric motor. A two-stage auxiliary compressor, direct coupled to an electric motor, supplies the compressed air at a pressure of 25 atmospheres (367 lb. per sq. inch), and acts as a spare for the main compressor. There are, further, two sets of electrically-driven sanitary and fire pumps; also an electrically-driven ballast pump, having a capacity of 150 tons per hour. An electrically-driven fuel oil pump is used to charge the daily service tanks with the daily supply of fuel oil; it is also used for trimming the oil.

The ship is rigged with four masts, and has one 30-ton, one 15-ton, twelve 5-ton and eight 2-ton derricks, twenty electric deck winches, and an electric windlass. The steering engine is hydraulic and electric. Besides the crew's quarters, aft of the ship, there is provided accommodation for 12 passengers in the deck house under the bridge.

The builders add that the machinery briefly described above is similar to that built by them and erected by Messrs. William Cramp and Sons, Philadelphia, in the motorship William Penn, belonging to the United States Shipping Board, which ship is now on her maiden voyage.

THE RELATION OF RUN-OFF TO RAINFALL: ERRATA.—Mr. F. S. Robins points out that in the report on page 147 of our issue of the 22nd inst. of the proceedings of Section VI of the Institution of Civil Engineers Conference, on Friday, July 1, he is stated to have spoken as the engineer to a large "trading" area. The words should have read "to a large drainage area." His second reason for ending his year in September is that that was also the end of the civil quarter. On the question of flow-off our report stated that Mr. Robins had to deal with a flow-off of 11 in. in 13 days. This should have read "a flow-off from 11 in. in 13 days."

CHINESE IMPORTS OF DYES.—The following are, in taels, figures of imports of dyes in China, issued by the Chinese Government Bureau of Economic Information:—

Imported from	Spring, 1921. Taels.	Spring, 1920. Taels.
Germany ...	538,387	No imports
U.S.A. ...	442,893	177,933
Holland ...	383,861	24,850
England ...	98,569	41,670
Japan	96,706	113,210
Total ...	1,560,416	357,663

As will be seen, the figures for Germany and Holland together exceed half the total for the Spring of 1921.

MEASUREMENT OF VIBRATION OF THE 660-FT. WIRELESS TELEGRAPH STATION TOWER AT HARANOMACHI.

By F. OMORI, Member of the Imperial Earthquake Investigation Committee.

1. *The Tower.*—The reinforced concrete tower of the new wireless telegraphy station of Haranomachi (Figs. 1 and 2), designed for the Department of Communications by Professors K. Shibata, Y. Nagayama, and I. Kaama, of the Tokyo Imperial University, is a hollow cone, with the apex truncated, which rises to the height of 660 ft. (= 201·2 m.), or 663·8 shaku* ; the external base diameter, is 57 ft. 9 in., being to the height in the ratio of 1 : 11. The external diameter at the top is 4 ft. 6 in., or nearly 1/13 of that of the base. The thickness of the concrete wall varies from 33 in. at the base to 6 in. at the top, the steel rods being embedded in the concrete at the depth of 2½ in. from the outside surface. The composition of the concrete was 1 : 2 : 4 both for the shaft and the foundation. The work of construction was carried on by the Oriental Compressol Company of Tokyo. (See Figs. 3, 4 and 5.) Table I gives the wall thickness and the median diameter (or the diameter of the cone midway between the internal and external surfaces) for successive 1/24th parts along the height of the shaft.

Structure.	Steel.	Concrete.
	tons.	
Foundation	79	225 cub. tsubo* = 2,930 tons
Shaft	290	550 cub. tsubo* = 7,160 tons
Total ...	369	775 cub. tsubo = 10,090 tons

* 1 tsubo = 6 shaku cube = 216 cub. shaku = 212·3 cub. ft.

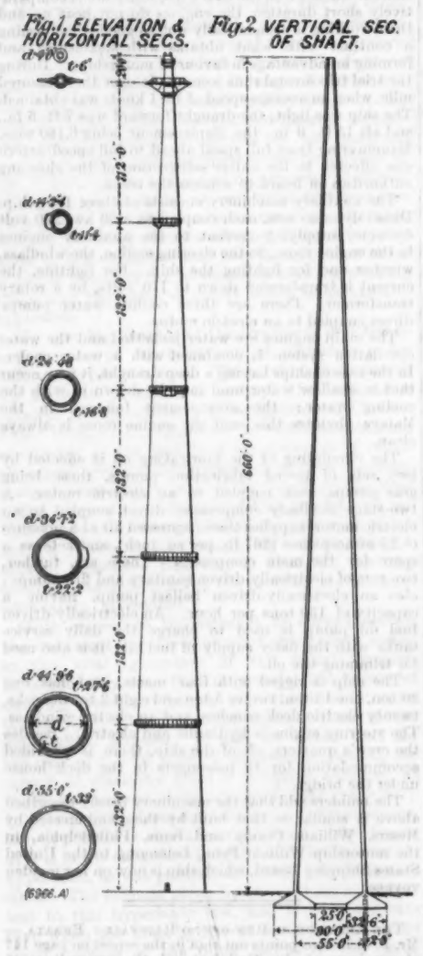
The total weight of the shaft is about 7,450 tons, of which 7,160 tons and 290 tons are respectively the weights of the concrete and of the steel. Again the total weight of the foundation is 3,009 tons, of which 2,930 tons and 79 tons relate respectively to the concrete and the steel. The ratio by weight of the steel to the concrete is 1 : 37 for the foundation and 1 : 25 for the shaft.

The work of the foundation construction was started on May 23, 1919, and the shaft, built successively in 147 divisions or layers of concrete deposit, each 4 ft. 6 in. in height, has been completed on September 26, 1920, at 3 p.m. The tower wall has no opening except one narrow entrance at the base, and four small windows, each 2 ft. square, at successive intervals 132 ft. in height.

TABLE I.—*Dimension, and the Amount of Material used in the Construction of the Tower.*

Height.	Median Diameter.*	Thickness of Wall.	Height.	Median Diameter.*	Thickness of Wall.
ft. in.	in.	in.	ft. in.	in.	in.
Base	660·0	33·00	357·6	328·5	18·38
27 6	634·5	31·88	385 0	303·0	17·25
55 0	609·0	30·75	412 6	277·5	16·13
82 6	583·5	29·63	440 0	252·0	15·00
110 0	558·0	28·5	467 6	226·5	13·88
137 6	532·5	27·38	495 0	201·0	12·75
165 0	507·0	26·25	522 6	175·5	11·63
192 6	481·5	25·13	550 0	150·0	10·5
220 0	456·0	24·00	577 6	124·5	9·38
247 6	430·5	22·88	605 0	99·0	8·25
275 0	405·0	21·75	632 6	73·5	7·13
302 6	379·5	20·63	660 0	48·0	6·00
330 0	354·0	19·5			

* Diameter from middle to middle of the concrete wall.



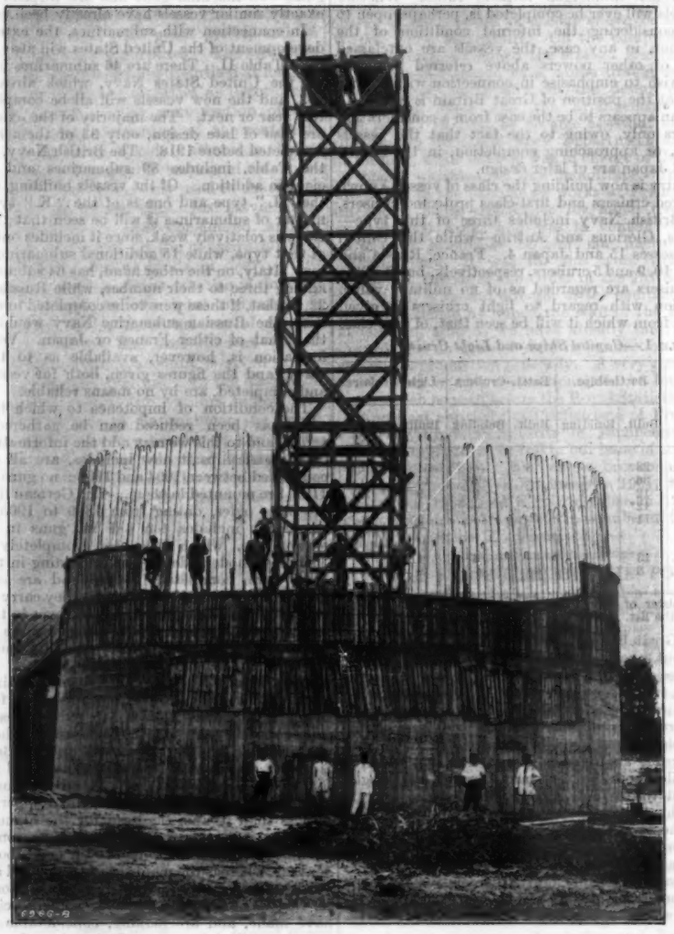


FIG. 3. THE HARANOMACHI, WIRELESS TOWER AT AN EARLY STAGE OF CONSTRUCTION.

2. *Nature of Soil.*—The tower stands on a narrow alluvial plain about the small River Shinden-gawa, passing between the low tertiary hilly districts. For the surface 4 ft. the soil is composed of black and red earths. Then comes a layer of sand about 4 ft. in thickness, lying upon a layer of clay 2 ft. thick. Next below comes a layer of gravel and sand more than 10 ft. in thickness, on which the foundation of the tower rests. The different formations are arranged horizontally, a circumstance favourable to the erection of a heavy structure.

We have no exact knowledge of the period of the earthquake vibration at Haranomachi, as no seismographic observation has been made there. For the sake of reference, I give in Table II the value of the period of large earthquake vibration measured seismographically at different places where the ground is composed of alluvial soil.

Of the different places here taken into consideration, Hitotsubashi, in the lower portion of Tokyo, is to be regarded as an example of deep and very soft alluvial soil; and the vibration period there is invariably about 1 second, both for small and large earthquake movements.

The maximum wind pressure taken into consideration in the designing of the tower was 60 lb. per square foot at the base, with an increment of 1 lb. per square foot for every 10 ft. height ascension, so that the pressure allowed for as the top is 126 lb. per square foot.

The amount of the material used in the construction of the tower with an allowable maximum pressure of 4·2 tons per square foot on the ground, was as given in the following summary :—

Foundation :—
- Diameter of the bottom area = 90 ft.
- Thickness (depth) .. .. = 12 ft.

Shaft :—
- Height .. .. .. = 660 ft.
- External diameter at base .. = 57 ft. 9 in.
- External diameter at top .. = 4 ft. 6 in.
- Wall thickness at base .. = 33 in.
- Wall thickness at top .. = 6 in.

Amount of concrete :—
- Foundation = 225 cubic tsubo = 47,759 cub. ft.
- Shaft .. = 550 cubic tsubo = 116,745 cub. ft.

Steel reinforcement :—
- Foundation .. .. .. = 79 tons.
- Shaft .. .. = 290 tons.

Diameter of steel reinforcement :—
- In the foundation = 1 in., ⅞ in., ¾ in.
- In the shaft .. = 1¼ in., 1 in., ⅞ in., ¾ in., ⅝ in., ½ in.

* 1 shaku, or Japanese foot = 0·99421 English foot.

At the Central Meteorological Observatory, close to Hitotsubashi, which stands on the castle ground surrounded by the gigantic ishigaki (stone retaining wall), the earthquake motion has a character somewhat similar to that at the hard ground of Hongo, where the Seismological Institute is situated. The Gifu and Kyoto meteorological observatories are situated on alluvial ground close to hills and may be considered as being not

much different from Haranomachi with respect to the character of the earthquake motion. The period of the destructive seismic motion at Haranomachi is probably 1 second to 1·2 seconds.

The zone of great destructive earthquakes lies off the Pacific coast at the mean distance of some 200 km. from Haranomachi, whose vicinity is also not likely to become the origin of a violent local shock. The maximum limit of the seismic intensity to be expected at Haranomachi may probably be taken to be about 1,000 mm./sec.²

3. *Method of Experiment.*—The measurement of the movement of the tower caused by winds has been carried on during the course, and after the completion, of construction, on five different occasions,* as follows :—

No. of Experiment.	Date of Experiment. (1920.)	Height of Structure.	Weather at the Time of Experiment.
		ft.	
1	May 23	290	S.E. wind, 5–10 m./sec.
2	July 10	414	Some rain ; very feeble N.E. wind.
3	Aug. 20	522	Some rain moderate S.E. wind.
4	Sept. 26 and 28	660	Easterly wind, moderately strong.
5	Nov. 5	660	N.E. wind, moderately strong.

4. *Weather during the Experiments.*—In the vibration experiments on the Haranomachi wireless tower I had not the good fortune of making observations in a violent storm as had been the case with the measurement relating to the great 550-ft. chimney at Saganoseki. In the second experiment, on July 10, when the tower height reached 414 ft., the weather was calm, the maximum wind velocity being only 4 m./sec. On the other four occasions, the winds were more or less strong, reaching at the top of the column the maximum velocity of 15 m./sec. to 20 m./sec. This is, however, very much lower than the wind velocity of 35 m./sec. observed on the top of the Saganoseki chimney (on December 26, 1916).

5. *Experiment on May 23, 1920.*—2.30–4.30 p.m.—On May 23, when the vibration measurement was first tried, the construction work had advanced up to the sixty-third concrete layer reaching the height of 290 ft. The external diameter and the thickness of the shaft at the top were respectively 34 ft. 4·24 in. and 21·14 in. Although the height attained so far was only $\frac{290}{660} = 44$ per cent. of 660 ft., the amount of the concrete used was a little over two-thirds of that for the entire structure. Thus at the forty-fourth concrete layer, or at $44/147 = 30$ per cent. of the total height, the volume of the concrete used had already been 325 cub. tsubo, namely, $325/550 = 59$ per cent. of the total required amount. The weight and the volume of the timbers composing the elevator trestle for the height of the 290 ft. were respectively 31 tons and 2,349 cub. ft., these amounts being approximately three-fourths of those for the entire wooden structure. The existence of the trestle, whose weight was quite insignificant, exercised no special influence on the motion of the shaft.

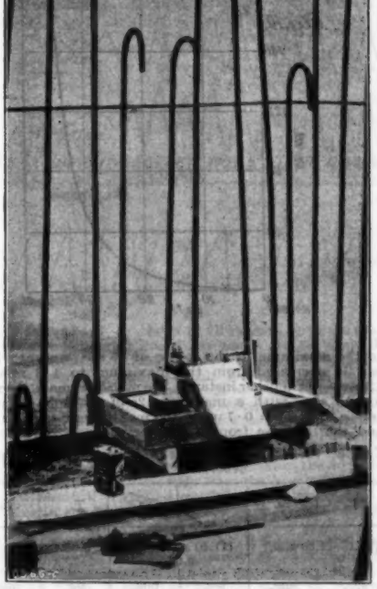


FIG. 4. VIBRATION RECORDER SET UP ON THE TOP OF THE SHAFT; MAY 23, 1920.

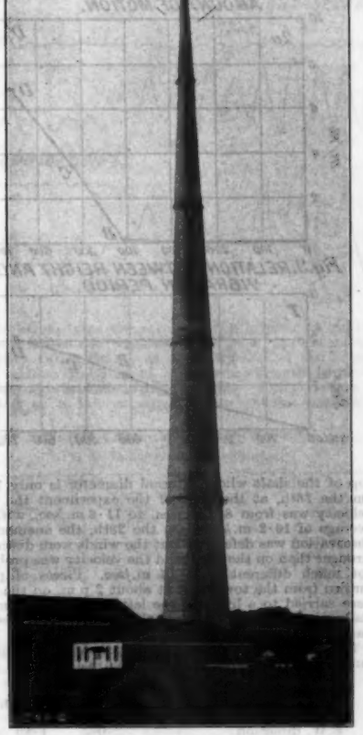


FIG. 5. THE TOWER AFTER ITS COMPLETION.

The ascension to the top was effected by means of a sort of elevator which was mounted on the temporary timber frame work erected inside the shaft, and which supplied the means of carrying up the building materials, no exterior staging having been employed. The total volume of the timber of the interior scaffold was 3,126 cub. ft., weighing about 42 tons. This is equal to only 1/178 of the weight of the shaft.

The motion was registered mechanically with ink on white paper by a portable two-component horizontal vibration recorder of 10 to 30 times magnification (Fig. 4), fixed on the top of the concrete wall, where a sort of plank flooring was provided to accommodate the people engaged in the measurement. The recording instrument was properly protected by a cover so that the steady masses and the writing indices were not subjected to direct disturbance by the winds. The wind velocity was read off from a Robinson's anemometer set up on the column top during the different experiments.

The double amplitude or range of motion, and the complete period of the tower vibration measured from different portions of the vibration-recorder diagrams are denoted in the following pages by the symbols 2a and T respectively.

Illustrative vibration diagrams are given in Figs. 6 and 7, and 11 to 13 on pages 198 and 199.

Time of Observation.	Motion Parallel to Shaft Wall.		Motion Normal to Shaft Wall.	
	T.	Max. 2a.	T.	Max. 2a.
p.m.	sec.	mm.	sec.	mm.
3.00—3.10	0·73	0·03	0·72	0·017
3.35—3.42	—	Small	0·72	Small

At the time of the experiment, 2.30 to 4.30 p.m., the wind was south-easterly, with the speed of 4½ m./sec. to 10½ m./sec., averaging about 6·8 m./sec. The vibration recorder was set up at the S.E. part of the top surface of the shaft, the two pointers being oriented to register respectively the component movements normal and parallel to the wall there.

TABLE II.—*Period of Large Earthquake Vibration observed at different Seismological Stations situated on Alluvial Plain.*

Place of Observation.	Date.	Time of Occurrence.	Maximum Motion = 2a.	Complete Period. = T
		p.m.	mm.	sec.
Hitotsubashi. (Tokyo).	Jan. 15, 1887	6·52·00	54·0	0·97
	Nov. 30,1894	8·30·57	10·5	1·00
	June 20, 1894	4·22·44	9·6 (E.W.) 6·5 (N.S.)	1·00
		p.m.		
Central Meteorological Observatory (Tokyo).	June 20, 1894	2· 4·10	76·0	1·3
	Jan. 18, 1895	10·48·24	41·0	0·9
		a.m.		
	Feb. 20, 1897	5·49·37	22·8	1·5
		p.m.		
	July 22, 1897	6·31·44	7·3	1·3
		a.m.		
	Apr. 29, 1888	10· 0·33	5·6	0·8
		a.m.		
Kyoto Meteorological Observatory.	Mar. 7, 1899	9·55·01	13·6 (E.W.)	0·84
	Jan. 18, 1895	p.m. 10·49·35	2·0 (E.W.)	0·97
	May 7, 1896	p.m. 6·37·31	1·4 (E.W.)	0·97
		p.m.		
Gifu Met. Obs.	Aug. 14, 1919	3·31·38	36·0	1·2
Hikone Met. Obs.	Aug. 14, 1909	3·31·38	22·0	1·1

TABLE III.—*Vibration of the Wireless Tower, 414 Ft. in Height. July 10, 1920.*

Time of Observation.	E.W. Component.		N.S. Component.	
	T.	2a.	T.	2a.
	sec	mm.	sec.	mm.
	—	Small	1·25	0·03
	1·25	0·03	1·29	0·04
8.00–8.20 a.m.	1·28	0·03	1·26	0·05
	1·23	0·07	1·27	0·04
	0·33*	0·38	0·35	0·09
	—	Small	1·23	0·06
	1·27	0·04	1·26	0·05
8.34–8.55 a.m.	—	Small	1·26	0·11
	1·25	0·05	—	Small
	1·25	0·04	1·23	0·04
	—	Small	1·25	0·04
	1·27	0·03	1·27	0·06
	—	Small	1·25	0·05
	1·27	0·03	1·23	0·03
9.20–9.40 a.m.	1·26	0·06	1·26	0·03
	1·23	0·05	1·27	0·07
	—	Small	1·22	0·08
	0·32†	0·05	—	No indication
	0·34	0·07		
	0·31	0·03		
	1·23‡	0·10	—	Small
	1·25	0·04	1·25	0·04
9.57–10.15 a.m.	1·25	0·06	1·23	0·04
	1·25	0·03	1·25	0·05

* One man shaking the staging at the top.
† Due to the working of the elevator within the staging.
‡ Disturbance caused by the falling down of a timber piece inside the shaft.

TABLE IV.—*Vibration of the Wireless Tower. Height = 522 Ft. August 20, 1920.*

E.W. Component.		N.S. Component.	
T.	2a.	T.	2a.
sec.	mm.	sec.	mm.
1·68	0·93	1·63	0·73
1·68	0·59	1·64	0·14
1·66	0·20	1·66	0·22
1·66	1·73	1·66	0·17
1·70	0·60	1·60	0·21
1·69	1·03	1·65	1·43
1·70	2·27	1·69	0·28
1·67	3·43	1·66	1·95
1·70	0·44	1·70	0·55
1·66	1·10	1·63	0·33
1·70	1·24	1·70	0·94
1·65	2·07	1·64	0·97
1·70	1·67	1·65	1·26
1·70	1·48	1·70	0·32

	Average Period. Sec.	Max. 2a. MM.
E.W. component	1·68	3·43
N.S. component	1·66	1·95

The motion of the shaft caused by the winds were entirely unfelt, and the instrumental diagrams indicated only extremely small vibrations even when registered with 30-time magnification. The result of the measurement are given in the preceding column.

The maximum motion was far below 0·05 mm., the reinforced concrete shaft so far constructed being very rigid.

6. *Experiment on July 10, 1920.*—8–10.30 a.m.—Height = 414 ft. (Table III. above.) On the occasion of this second experiment the weather was unfortunately

* I state here my obligations to Dr. Y. Nagayama, assistant professor of civil engineering in the Tokyo University, and Mr. I. Fujiwara, official superintending the construction of the tower at Haranomachi, who kindly afforded me much assistance in the measurement of the vibration.

very calm, the wind velocity varying between 1·5 m./sec. and 4 m./sec., with the average of 2·3 m./sec. The vibration was as follows :—

E.W. component.
Average T = 1·253 sec., max. 2a = 0·10 mm.
N.S. component.
Average T = 1·252 sec., max. 2a = 0·11 mm.

The general average value of the period was 1·25 sec. There were also the quick movements of an average period of 0·33 sec. which were due to disturbances of the inside elevator trestle.

7. *Experiment on August* 20, 1920.—Noon to 2.35 p.m. —The height of the shaft was 522 ft., the top external diameter being 16 ft. The wind was south-easterly and moderately strong, so that no workman dared to ascend the shaft, and the work of construction had been abandoned for the day. The wind velocity varied between 10 m./sec. and 20 m./sec., with the average of 14 m./sec. After 2.35 p.m., it rained.

The results of the measurements with the tremor-recorder set up at the E. part of the shaft top are given in Table IV.

The general average period was 1·67 sec. The motion was greater in the E.W. than in the N.S. component. (See Figs. 11 and 13.)

8. *Experiments on September* 26 *and* 28.—Height = 660 ft. The vibration measurements were executed immediately after the completion of the construction of the tower. The vibration recorder was set up at the top of the shaft, whose internal diameter is only 3½ ft. On the 26th, at the time of the experiment the wind velocity was from 8·7 m./sec. to 11·8 m./sec., with the average of 10·2 m./sec. On the 28th, the anemometer observation was defective, but the winds were distinctly stronger than on the 26th, and the velocity was probably not much different from 15 m./sec. Pieces of paper thrown from the tower top at about 2 p.m. on the 28th were carried to a little to the left of the Haranomachi Railway Station, indicating that the wind direction was toward the W. and slightly S.

The movements in the two component directions are summarised in Table V, from which we find :—

	Average Period. sec.	Max. 2a. mm.
E.W. direction	2·065	1·86
N.S. direction	2·075	6·90

The general average value of the period was 2·07 sec. In the measurements on September 28, the motion in the N.S. was invariably much greater than that in the E.W. component ; the maximum movements in these two directions being respectively 1·86 mm. and 6·90 mm., nearly in the ration of 1 : 4. As the wind at the time of the observation was very nearly easterly it follows that the tower made pronounced movements, not parallel, but at right angles to the direction of the wind. (See Figs. 6 and 7.)

In the E.W. component diagrams of motion, there occurred often the quicker vibration of the average period of 0·86 sec. (max. 2a = 0·4 mm.). This was probably resulted from the shaking of the inner elevator trestle due to the impact of winds. Its period was exactly double that of the movement in the N.S. component (T = 0·43 sec., max. 2a = 1·14 mm.) produced by disturbing the trestle.

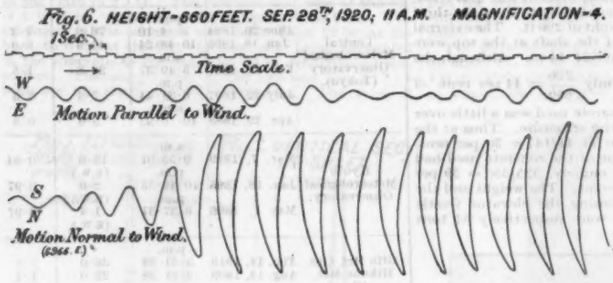
9. *Experiment on November* 5, 1920.—11 a.m. to 1 p.m.—Height = 660 ft. This experiment was repeated in order to find out the change in motion of the reinforced concrete shaft caused by the subsequent addition of a rhomboidal iron frame, of length = 38 ft. and of weight = 5,200 lb. attached 20 ft. below the top. By this time 16 metal pulleys for supporting the antenna wires had been fixed on the top surface which forms a ring of an inner diameter of only 3½ ft. and of width of 6 in. Owing to the want of space it was found possible to set up only a single-component tremour-recorder, which measured the E.W. vibrations with 10 times magnification.

The winds were north-westerly and fairly strong, the velocity at the tower top being 7·7 m./sec. to 15·4 m./sec., with the average of 10·6 m./sec. On this occasion there seemed to be no very great difference in the force of wind at the top and the base of the shaft.

The wind velocity measured at 2 p.m. on the ground was from 8 m./sec. to 11 m./sec. As shown in Table VI, the tower vibration was greatest at about 11 a.m., and attained a 2a of over 10·3 mm. In one instance the motion remained pronounced for an interval of 83 sec., at whose commencement the 2a increased from 1 mm. to the maximum in the course of 19 sec., and at whose end it decreased from the maximum to 1·8 mm. in 13 sec. On another instance, the motion remained active for 15 sec., with a maximum 2a of 9·4 mm. ; the increase from 2a = 0·7 up to the maximum taking 12 sec. and the decrease from the latter to 2a = 2·3 mm. in 9 sec. The general average value of the period works out to be 2·12 sec. This is about 0·05 sec. longer than the period of the tower previous to the attachment near the top of the rhomboidal iron frame, and represents the effect due to the addition of the extra weight. The greater motion observed on the present occasion may be due to the exposure of the surface of the frame in question to the winds.

10. *Summary.*—The results of the different measurements are collected in Table VII, from which it may be observed that the movement of the structure was insignificantly small (= 0·03 mm.) even when the height reached 290 ft. Thus, so far as the amount of motion was concerned, the column formed up to that height virtually a part of the foundation. It was only after the height had risen above 500 ft. that the vibration became very marked. (See Fig. 8.) The maximum motion of the tower at its completion was 6·9 mm., which was increased to over 10·3 mm. by the addition of the iron frame at the top.

The vibration period of the structure was 0·72 sec. at the height of 290 ft. Thereafter the period gradually



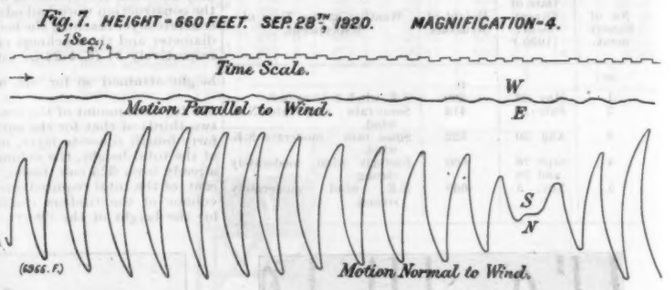
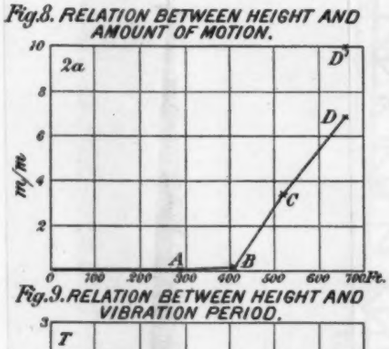
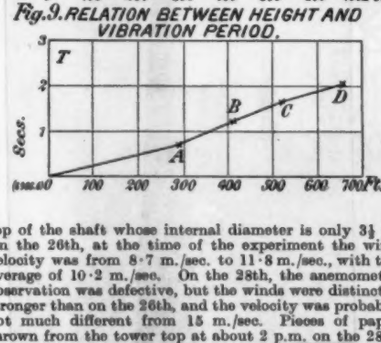


TABLE V.—*Vibration of the 660-Ft. Wireless Tower. September 26 to 28, 1920.*

Time of Observation.	E.W. Component. T.	E.W. Component. 2a.	N.S. Component. T.	N.S. Component. 2a.
	sec.	mm.	sec.	mm.
	0·85	0·07	2·06	0·83
	2·05	0·20		
	2·06	0·60	2·06	1·23
	2·05	0·60	2·06	1·43
	0·86	0·17	2·12	0·22
	2·06	0·23		
	0·86	0·10	2·08	0·19
	2·12	1·03	2·10	2·83
September 26, 4.30–5.10 p.m.	2·07	0·57	2·04	2·57
	0·85	0·13	2·12	0·13
	2·07	0·60	2·06	1·10
	2·01	0·47	2·04	0·57
	2·05	0·53	2·05	0·53
	0·85	0·27	2·05	0·25
	2·05	1·03	2·06	0·20
			0·84	0·07
	0·86	0·40	2·10	1·57
	2·11	1·17	2·09	2·03
	2·09	1·86	2·19	6·74
September 28, 11.00–11.25 a.m. (E. wind.)	2·02	0·70	2·02	5·40
	2·10	0·80	2·09	6·34
	2·07	0·50	2·05	6·40
	2·04	1·06	2·10	6·60
	2·01	1·40	2·08	6·90
	2·06	0·66	2·05	6·64
	2·10	0·46	2·03	6·86
	2·06	0·50	2·07	6·66
	2·04	0·46	2·06	6·34
	0·87	0·20	2·10	5·46
	2·00	0·20		
	2·10	0·60	2·04	3·20
	2·02	1·20	2·07	6·60
September 28 ; 11.00–11.25 a.m. (E. wind.)	1·98	0·44	2·08	6·54
	2·05	2·00	2·06	6·86
	2·10	0·46	2·07	6·86
	2·03	1·14	2·00	5·16
	2·10	1·14	2·11	5·80
	2·04	0·76	2·04	6·84
	0·86	0·08	2·09	5·76
	2·05	0·76	2·10	6·60
	2·09	0·20	2·04	4·54
	2·03	0·20	2·05	6·70
	2·09	0·97		
September 28 ; 1·00–1.40 p.m.	2·09	0·78		
	2·11	0·82		
	2·11	0·99		
	0·84	0·06		
			2·08	1·88
September 28 : 1.45–2.00 p.m.			2·11	2·14
			2·04	1·15
			2·11	1·50
			2·06	2·78
			2·15	3·55
			2·08	1·93
September 28 ; 2.04–2.20 p.m.			0·43*	1·90
			0·43*	1·14
			2·06	1·47
			2·05	1·57
			2·04	1·64
			2·10	1·17
			2·11	1·82
September 28 ; 2.25–2.36 p.m.			2·11	3·43
			2·10	2·00
			2·09	2·03
	0·86	0·10		
	0·87	0·10		
September 28 ; 2.40–3.00 p.m.	2·09	0·31		
	2·09	0·29		
	2·11	0·57		
	0·84	0·07		

* A man disturbed the staging.





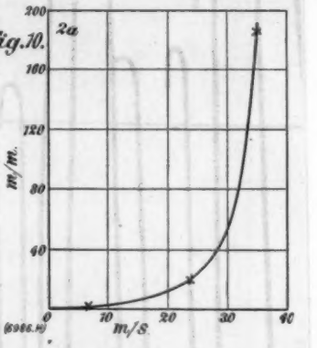


TABLE VI.—*E.W. Component Motion of the Tower. November 5, 1920.*

T.	2a.	T.	2a.	T.	2a.
(11.15–11.30 a.m.)		(11.40 a.m.–0.10 p.m.)		0.35–0.50 p.m.)	
sec.	mm.	sec.	mm.	sec.	mm.
2·10	4·5	2·08	2·8	2·0	1·4
2·14	2·1	2·12	3·8	2·2	4·0
2·12	10·3	2·05	2·0	2·1	5·3
2·08	10·3	2·09	5·5	2·2	4·5
2·20	9·4	2·10	3·5	2·1	0·9
2·18	5·3	2·15	4·0	2·2	2·1
2·10	3·5	2·09	4·9	2·1	1·4
2·08	5·4	2·10	5·1	2·1	5·4
2·07	4·6	2·10	3·0		
2·10	3·9	2·13	3·6		
2·10	4·3	2·22	2·3		
2·10	5·8	2·18	3·6		
2·08	3·7	2·15	3·6		
2·08	3·2	2·10	3·8		
2·12	5·7				
2·10	4·5				

increased up to 2·07 sec. at the completion of the full height of 660 ft. (See Fig. 9.) The addition of the iron frame near the top lengthened the period to 2·12 sec. The subsequent attachment of the antennæ wires has probably prolonged the period a little further. The tower may thus probably be considered as a tall column with respect to earthquake motion.

TABLE VII.—*Maximum range (2a) and Mean Period (T) of the Vibration of the Haranomachi Wireless Tower at Different Stages of Construction.*

Height.	Maximum Wind Velocity.	Oscillation of the Shaft.	
		T.	Max. 2a.
ft.	m./sec.	sec.	mm.
290	10·5	0·72	0·03
414	4·0	1·25	0·11
522	20·0	1·67	3·43
660	15·0	2·07	6·90*
660	15·4	2·12	Over 10·30†

* At the first completion of the tower construction.
† After the addition of the iron frame at the top.

A point of special interest is the verification of the relation of the direction of the maximum vibration to that of the wind already found in the case of the Saganoseki chimney experiments. The measurement on the top of the wireless tower on September 28, 1920, indicated that the structure moved principally, in direction not parallel, but at right angles to the winds which blew nearly from the east; the N.S. vibrations, with the max. 2a = 6·9 mm., being invariably much greater than the E.W. vibrations, of max. 2a = 1·9 mm. This fact of the transversal motion, which has analogies in the behaviour of banners flowing in winds or of flexible strings and rods immersed in a water stream, must be due to the great pressure of strong winds, which produces a more or less perfect vacuum behind, and sensibly bends, the column. It will be easier for the latter to move transversally than against the winds in the direction of the bending. Professor H. Nagaoka has published a hydrodynamical explanation of the phenomena in question in the Proceedings of the Physico-Mathematical Society of Japan, October, 1919.

Fig. 11. HEIGHT 522 FEET. AUG. 20TH, 1920; 2.28 P.M. MAGNIFICATION-7·5.

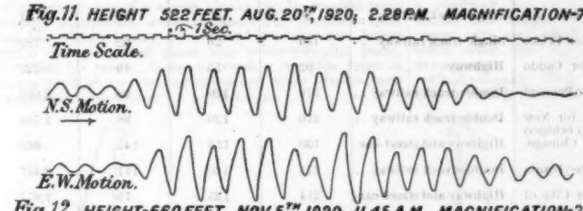


Fig. 12. HEIGHT-660 FEET. NOV. 5TH, 1920; 11.45 A.M. MAGNIFICATION-2·5.

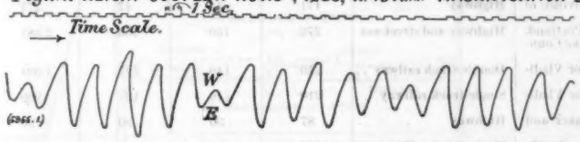
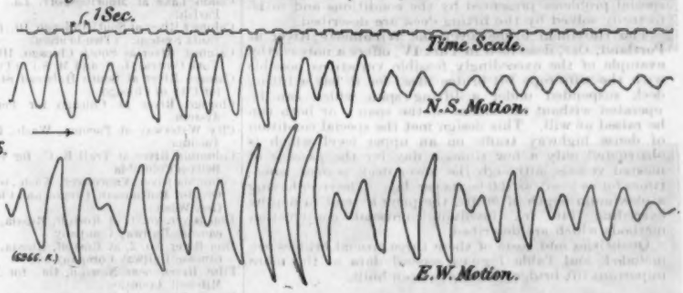


Fig. 13. HEIGHT-522 FEET. AUG. 20TH, 1920; 0.10 P.M. MAGNIFICATION 7·5.



11. *Comparison with Saganoseki Chimney.*—The great 550-ft. reinforced concrete chimney at Saganoseki has base and top external diameters respectively of 42 ft. 8 in. and 27 ft. 5 in. The wireless tower at Haranomachi has a more tapering form, being taller, but broader at base, and narrower at top. For the wind velocity of 1 m./sec. to 6·9 m./sec., the max. 2a of vibration of the Saganoseki chimney was 0·13 mm. to 0·72 mm., which was increased to 20·4 mm. and 186 mm. respectively at the velocities of 24 m./sec. and 35 m./sec. From the diagrammatic representation in Fig. 10, the motion of the same chimney at the wind velocity of 15 m./sec. seems to be some 5 mm. or 6 mm.

The movement of the 660 ft. wireless tower at Haranomachi due to winds in the condition experimented upon at its completion on September 26 to 28, 1920, was nearly equal to or slightly greater than the corresponding one of the Saganoseki chimney, and might have been increased to vibrations of 2a reaching ½ ft. to 1 ft. in a storm with a wind velocity of 30 m./sec. to 40 m./sec. at the top of the tower. The addition of the iron frame near, and the stretching of the wires over the pulleys, at the top, may modify the motion of the tower to a certain extent; the former increasing, and the latter tending to damp and prevent the accumulation of, the vibrations.

12. *Stability of Columns.*—To compare the stability of different bodies with the earthquake motion let us denote by A and y_0 respectively the total height and the height of centre of gravity of a column. For a solid or hollow cylinder or prism, namely, a column of uniform section, we have: $y_0 = \frac{1}{2} \times H$. For a solid or hollow cone, the centre of gravity is only half so high: $y_0 = \frac{1}{4} \times H$.

For a parabolic column,* square or circular in section, which offers a uniform resistance to seismic fracturing, the height of the centre of gravity is only one-third of that of a cylinder or prism: $y_0 = \frac{1}{6} \times H$.

Now turning our attention to ordinary brick factory chimneys we find that the centre of gravity of the main shaft is situated almost exactly at one-third of the total height. For instance, in a brick chimney of circular section, 100 shaku in height, at the Oji Goryokyok factory, near Tokyo, the height of the centre of gravity is 33·9 shaku, $= \frac{1}{3} \times 100$ shaku nearly. Again, the height of the centre of gravity of the tall 80-m. brick chimney of the Imperial Iron Works at Yawata, Kyushu, is found to be 26·8 m. $= \frac{1}{3} \times 80$ m. exactly.

Of the wireless tower at Haranomachi, the values of the volume (= V) and the height (= y_0) of the centre of gravity of the shaft are as follows:—

$$V = H \times 18 \times 230 \times 2\pi \text{ cub. in.} = 119{,}000 \text{ cub. ft.}$$

$$y_0 = H \times \frac{261}{4 \times 230} = 187 \text{ ft.} = \frac{1}{3.5} \times H \text{ nearly.}$$

As far as the height of the centre of gravity is concerned the wireless tower ranks between a cone and a common brick chimney. In the case of the great 550-ft. reinforced concrete chimney at Saganoseki, the centre of gravity is approximately equal to $\frac{1}{2 \cdot 8} \times H$; the total volume of the shaft being 73,652 cub. ft. (see Table VIII).

The resistance of a cylinder or prism with a given base dimension, supposed to be a short column,* to fracture by the horizontally applied earthquake motion, varies inversely as the square of the height. A conical column is likewise weakest at the base, but its seismic stability varies simply as the reciprocal of the height. The seismic stability of a uniform-strength parabolic column is independent of the height. If a structure be treated as a tall column,* whose natural oscillation period is sufficiently long in comparison with the period of the destructive earthquake motion, it will, or tends to, be broken in the vicinity of the height (= h) corresponding to the centre of percussion of the body with respect to the ground surface. The height h is $\frac{2}{3} \times H$ for a uniform section column, $\frac{2}{5} = H$ for a cone, and $\frac{2}{7} = H$ for a parabolic uniform strength column. For brick chimneys, $h = \frac{53}{100} \times H = \frac{2}{4} \times H$ approximately. For the wireless tower at Haranomachi, this height is situated at about 295 ft. above the ground, or $\frac{1}{2 \cdot 24} \times H = \frac{2}{4 \cdot 5} \times H$ approximately. The tower is probably to be regarded as being seismically weakest at the height of about 300 ft., which also marks the point above which the structure becomes comparatively much more shaky.

TABLE VIII.—*Stability of Columns.*
H = Total height of column.

Column.	Height of Centre Gravity.	h.	Seismic Stability.
Cylinder or Prism (Uniform section Column)	$\frac{1}{2} \times H$	$\frac{2}{3} \times H$	varies as $\frac{1}{H^2}$
Cone	$\frac{1}{4} \times H$	$\frac{2}{5} \times H$	varies as $\frac{1}{H}$
Parabolic Uniform-strength column	$\frac{1}{6} \times H$	$\frac{2}{7} \times H$	Constant.
100-shaku brick chimney at Oji, near Tokyo	$\frac{1}{3} \times H$ = 33·9 shaku	$\frac{54 \cdot 4}{100} \times H$ = 54·4 shaku	—
80-m. brick chimney at Yawata, G.I.W.	$\frac{1}{3} \times H$ = 26·8 m.	$\frac{53 \cdot 3}{100} \times H$ = 42·6 m.	—
550-ft. chimney at Saganoseki, Kyushu	$\frac{1}{2 \cdot 8} \times H$ = 194·2		
660-ft. wireless tower at Haranomachi	$\frac{1}{3 \cdot 5} \times H = 187'$	$\frac{1}{2 \cdot 24} \times H = 295'$	

* See the publications of the Imperial Earthquake Investigation Commission, No. 4.

* See the publications of the Imperial Earthquake Investigation Commission, No. 4.

13. *Deflection of Column.*—The present series of observations were aimed at the direct measurement of the vibrations of the structure. Only in the case of the experiment on November 5, 1920, was the deflection of the tower, loaded with the iron frame, caused by winds, shown more or less distinctly on the vibration recorder diagram by the displacement of the zero position of the writing pointer. The large horizontal vibrations observed on September 28, 1920, before the tower had been loaded with the iron frame, were the effect of accumulated motion dependent on the duration of the continuance of the wind gust. These increased much more quickly than the increase of the wind velocity. These movements, which were at right angles to the direction of the strong wind, were probably larger than the deflection of the column in direction of the latter. Again, the displacement caused by the sudden occurrence of wind gust after an interval of lull may correspond to the deflection in question. Such a movement in the component parallel to the wind direction was, however, never conspicuously large, a fact verified also in the case of the experiments with the great 550-ft. chimney at Saganoseki. From this consideration I am led to the conclusion that the amount of the deflection of the last-named structure and of the wireless tower at Haranomachi in the direction of the wind were smaller than the range of the vibrations normal to the wind.

VERTICAL LIFT BRIDGES.*

By ERNEST E. HOWARD, M.Am.Soc.C.E.

Synopsis.—The purpose of this paper is to outline the development of the vertical lift bridge, to discuss its principal elements, and to describe noteworthy features of some structures in which it is used. Part I deals with the general elements of lift-bridge design; Part II describes a bridge with a lifting span, the Columbia River Interstate Bridge; Part III describes a bridge with a lifting deck, the North Kansas City Bridge; and Part IV describes a bridge with a lifting span which has a lifting deck, the Harriman Bridge over the Willamette River at Portland, Ore.

Twenty-five years ago the swing span was almost the only type of movable span in use, but its limitations and deficiencies brought engineers to devise spans which would move vertically instead of horizontally. These include many ingenious bascule bridges which rotate in vertical planes, and the lift bridge which moves vertically. Although a rare type twelve years ago, more than 40 lift spans have since been built, many in large and important structures. Since only fragmentary information about these structures has hitherto been available, the writer undertakes to describe in some detail the essential features of the foregoing bridges, as containing elements which typify the development of the lift-bridge idea, and as showing adaptability to widely varying conditions and limitations.

The paper indicates the advantages of the lift bridge—economy in construction, rapid operation at low cost, determinate stresses, and no new stress conditions introduced during operation. It may within reason be of any length, any width, of any material, and with any type of floor and pavement. Future alterations in the lifting span, or its floor, and future grade changes are readily allowed for; and the effect of wind on operating machinery is very slight. It is shown that few engineering elements are more reliable, efficient and widely used than wire ropes, and most important lift spans are suspended by such ropes, although built-up chains, wrought chains, systems of levers, &c., have been considered and even tried. For counterweights for lift bridges cast-iron has been used, but concrete built around a steel framework is commonly used as it costs less than one-third as much as cast-iron.

The paper illustrates the operating machinery—

* Paper read before the American Society of Civil Engineers, May 4, 1921.

ordinary hoisting equipment, simple and easily adjusted, and indicates that simple spur gearing ordinarily suffices, the longest shaft extending transversely from truss to truss. Electric or hand brakes, limit switches for automatic emergency stops, gasoline engines or electric motors, suitable position indicators, &c., are used.

Direct comparison of the operation of various types of movable spans in which the lift span is found to operate more quickly and cost less per operation than adjacent swing and bascule bridges, is made, speed of operation being due to the fact that the lift span need only be lifted high enough to pass the approaching boat (often only 15 ft. or 20 ft.), and that there are no wedges or locks to be driven after the span is seated.

The Columbia River Interstate Bridge described in Part II includes a simple lift span 275 ft. long, 50 ft. wide, with a concrete floor and sidewalk, which will lift to a clear height of 150 ft. Two others of the 29 spans of the structure are arranged to be converted into lift spans by the erection of towers, counterweights, machinery, &c., should increased navigation require it. The somewhat unusual methods of pier construction, superstructure, erection, pumping, embankment approaches, floor details, low construction costs, and the public requirement of the property without taxation, are notable in this bridge.

It is shown that the lift-bridge idea may be applied not only to lifting spans, but also to a bridge floor supported at several points along its length, called a lifting deck, Part III, which is peculiarly adaptable to double-deck structures. In older forms, of which a few small spans have been built, the lifting deck and its counterweights were supported from the overhead trusses. The later structures, as described, relieve the supporting trusses of about half this load by placing the counterweights at the ends of the span. The North Kansas City Bridge over the Missouri River has a lifting deck, 425 ft. long, serving a double-track railway. The special problems presented by the conditions and satisfactorily solved by the lifting deck are described.

The Harriman bridge over the Willamette River at Portland, Ore, described in Part IV, offers a noteworthy example of the exceedingly feasible variations possible with the wire-rope lift-bridge idea, for it has a lifting deck suspended under a lifting span which can be operated without movement of the span; or both can be raised at will. This design met the special condition of dense highway traffic on an upper level which is obstructed only a few times a day for the passage of masted vessels, although the lower deck is open sometimes for as many as 100 boats per day. The river having a maximum depth of 90 ft., the piers extend to depths exceeding 140 ft., involving unusual construction methods which are described.

Quantities and costs of these three special bridges are included, and Table I gives general data of the more important lift bridges that have been built.

PART I.—GENERAL ELEMENTS OF DESIGN.

The lift bridge is of ancient origin. Several small lift spans were built in Europe prior to 1850. Concurrently in this country similar designs, or inventions, were made, as lift-bridge patents were granted at early dates to Messrs. McNeal, who secured a broad basic patent, Post, Whittemore, and the late Squire Whipple, Hon. M.Am.Soc.C.E. Lift bridges were occasionally proposed, but none more important than canal crossings was built until, in 1893, J. A. L. Waddell, M.Am.Soc.C.E., designed the bridge at Halstead-street, Chicago, Ill., over the Chicago River, which is still in service.* After that time a few small bridges were built over the Erie Canal, but fifteen years elapsed before the idea was applied to any large structures, when the development herein discussed began.

The principal element of the lift bridge, in its simplest form, is a simple span equipped with machinery for operation, suspended at each end by wire ropes which pass over sheaves on towers and connect to counterweights about equal to the span weight. Variations in almost every feature have developed: towers may be in part supported on adjacent spans; four vertical columns per tower, with four sheaves may be used; both towers and span may be square or skewed in plan.

When the lift span is short, the rear bracing of the towers may be omitted and overhead struts used instead. Where the lift movement is small, each column may be independent, the sheaves placed transverse to the span, and two counterweights hung outside the columns at each end. In one bridge the columns are part of the lift span, and extend down as legs into wells in the piers; the sheaves are on the piers and the counterweights are suspended underneath the floor, thus no tower or machinery is above the deck. Towers may be of steel, wood, or concrete; concrete towers may be treated architecturally and excellent appearance secured.

Adaptability and Economy.—In some alluvial rivers the location of deep-water channels varies through periods of years. Large expenditures occasionally have been made to construct additional movable spans or to maintain a channel under an existing span. This condition may be met by the use of equal spans, as any span can be made to lift and the towers supported on adjacent spans; towers and machinery may be removed from one location and re-erected in another. Similarly, a bridge may first be constructed with fixed spans, and, later, one span may be made movable; also, towers and machinery may be installed and an old fixed span converted into a lift span, thus economically providing for navigation.

Substructures as well as superstructures must be considered in determining comparative economics of movable spans. Tower piers of lift bridges differ little from ordinary piers. The added loads are vertical and do not change in amount or position during span movement, wind excepted. The elaborate protection pier, common with the swing span, is not necessary, and the lift span shows its greatest comparative economy where foundations are deep or expensive, or are carried on piles. For narrow openings where vessels with lofty masts must be accommodated a bascule is preferable; but where the vertical clearance required does not exceed the channel width, the lift span is found to be nearly always cheaper than the swing bridge or bascule, notably for long spans.

Qualities of Wire Rope.—The qualities of wire rope are essential features of lift-bridge development. A wire rope composed of steel wires twisted into strands which are twisted about a central rope or strand of wires or oil-saturated hemp, is much more elastic than the elements composing it and more flexible than a bundle of the same wires wrapped together straight. Extreme fibre stresses from bends of large radius are very small. Steel of great tensile strength can be used, and no other flexible tension member can approach so small a cross-section with equal strength. Each wire and the finished rope can be tested and an element of marked homogeneity secured of varying characteristics as desired.

The life of a wire rope operating over a sheave is a function of the number of operations. Biggart's experiments* with sheaves up to 42 rope diameters developed that the first wire will break approximately at the mid-point of rope life in operations. Applied to sheaves of 60 diameters, his formulas indicate a rope life of about 1,000,000 operations, or for a bridge, say, 50 operations daily up and down for twenty-five years. Such rope life appears to be extreme, but the Halstead-street Bridge has been in service twenty-seven years and has operated probably 200,000 rope bendings. The main suspending ropes originally placed are still in service, and when last examined by the writer no indications of failure were found. Yearly examination of suspending ropes will give timely warning of approaching weakness long before replacement is necessary. With suitable connections such replacement can be made without interference with traffic or bridge movement.

Forged steel sockets of full rope strength are used to connect ropes to structural parts. The load on a group of ropes of unequal length or uneven stretch may be distributed equally to each by equalizing bars or levers. A clamp on the ropes just below the sheave prevents movements of equalisers due to rope divergence, yet leaves every rope free to equalise.

Suspending Sheaves.—Suspending sheaves of 60 to 80 rope diameters afford satisfactory proportions between direct tension and bending stresses in ropes. Grooved sheaves of single steel castings, or of cast rim sections and hub riveted to structural webs are used. Composite sheaves not fully riveted are not satisfactory unless the shop work is better than is ordinarily the case. Sheaves 12 ft. in diameter, 36-in. face, have been supplied as single castings.

The two sheaves on a tower are quite independent, and slight variations in position cause no difficulty provided only that each pair of bearings are in proper relation. The sheaves can be skewed and the suspending ropes led directly from lift-span truss to counterweight, or the sheaves can be set in any lateral position and the ropes connected to a portal girder of the lift span.

Operating Machinery.—Operation can be effected by causing the tower sheaves to revolve synchronously by connecting shafts or similar mechanisms, or operating

TABLE I.—LIFT-BRIDGE DATA.

Bridge Over.	Kind of Traffic.	Length of Lift Span, in Feet.	Maximum Clear Height Above High Water, in Feet.	Normal Height of Movement, in Feet.	Total Moving Load—Span, Counterweights, &c., in Tons.
Arkansas River, near Ft. Smith, Ark, for Ft. Smith-Van Buren Bridge Company	Railway, street-car and highway	102	55	50	1,599
Arkansas River, near Watson, Ark., for Missouri Pacific System (M. H. and L. Railway)	Single-track railway ..	208	60	55	786
Bray's Bayou at Harrisburg, Tex., for Harris County	Highway	48	26	10	346
Bray's Bayou at Harrisburg, Tex., for Southern Pacific System	Single-track railway ..	48	20	17	54
Black River, near Jonesville, La., for Louisiana and Arkansas Railway Company	Single-track railway ..	165	55	53	579
Big Choctaw Bayou, Southern Louisiana, for Southern Pacific System	Single-track railway ..	50	47	40	71
Big Warrior River at Cordova, Ala., for Frisco System	Single-track railway ..	184	26	22	789
Caddo Lake at Mooringsport, La., for Caddo Parish.	Highway	92	55	49	223
Calumet River at South Chicago, Ill., for Pennsylvania System. (Two bridges)	Double-track railway ..	210	120	98	2,052
Calumet River at South Chicago, Ill., for New York Central (L. S. and M. S.) (Two bridges)	Double-track railway ..	210	120	98	1,784
Chicago River at South Halstead St., Chicago, for City of Chicago	Highway and street-car	130	155	142	660
Chicago River at Chicago for Pennsylvania System	Double-track railway ..	273	120	111	3,437
City Waterway at Tacoma, Wash., for City of Tacoma	Highway and street-car	214	135	75	1,677
Columbia River at Trail B. C., for Province of British Columbia	Highway	171	55	47	271
Columbia River, Vancouver, Wash., to Portland, Ore, for Multnomah, Oregon and Clarke Counties, Wash.	Highway and street-car	272	150	136	2,581
Don River No. 1, at Rostoff, Russia, for Vladicaucase Railway Company	Double-track railway ..	210	140	127	1,694
Don River No. 2, at Rostoff, Russia, for Vladicaucase Railway Company	Single-track railway ..	210	140	127	980
Flint River, near Newton, Ga., for Baker and Mitchell Counties	Highway	87	35	30	90
Illinois River, near Pekin, Ill., for Chicago Northwestern System	Single-track railway ..	173	55	39	785
Little River, near Jonesville, La., for Louisiana and Arkansas Railway	Single-track railway ..	118	45	41	396
Mississippi River at St. Paul, Minn., for Chicago Great Western Railway	Single-track railway ..	189	58	53	880
Mississippi River at Kethaburg, Ill., for Iowa Central Railway Company	Single-track railway ..	230	55	45	980
Missouri River, near Snowden, Mont., for Great Northern System	Single-track railway ..	296	50	40	1,621
Missouri River at Kansas City, Mo., for Union Depot and Terminal Railway Company	Double-track railway, street-car and highway double-deck	426	65	45	1,595
Missouri River at Yankton, S. Dak., for Meridian Highway Bridge Company	Single-track railway and highway	246	38	31	1,762
Oromocto River, near Fredericton, N.B., for St. John and Quebec Railway	Single-track railway ..	58	78	56	152
Puyallup River at Tacoma, Wash., for City of Tacoma	Highway and street-car	161	135	112	982
Red River, near Index, Tex., for Red River Bridge District	Highway	200	55	50	825
Sacramento River at Tehama, Cal., for Tehama County	Highway	167	65	59	271
St. Francis River, near Memphis, Tenn., for Missouri Pacific System	Single-track railway ..	162	70	68	582
St. Johns River at Jacksonville, Fla., for Duvall County.	Highway and street-car	188	165	108	1,458
Thompson River, near Kamloops, B.C., for Canadian Northern Railway	Single-track railway ..	90	55	53	219
Willamette River at Portland, Ore, for City of Portland	Highway and street-car	244	135	110	1,825
Willamette River at Portland, Ore, for Harriman System (O. W. R. and N. Co.)	Double-track railway, street-car and highway, double-deck	UD 211 LD 211	140 140	89 46–89	3,575 1,010 4,585
Willamette River at Harrisburg, Ore., for Northern Pacific	Single-track railway ..	200	70	60	678
Willamette River at Salem, Ore., for South-Pacific System	Single-track railway ..	131	55	51	479
Yellowstone River, near Fairview, Mont., for Great Northern System	Single-track railway ..	271	50	40	1,423

* Transactions, Am.Soc.C.E., Vol. xxxiii (1895), page 1.

* Biggart on "Wire Ropes," Minutes of Proceedings, Inst.C.E., Vol. ci, page 231.

drums and machinery may be placed in or under one tower. Rack and pinion operation is possible for small spans, but has not been used for any large ones.

The most used and most approved operating machinery comprises operating drums with motor attachment on the lift span controlling operating ropes, Fig. 1. Near the middle of the span are four spirally-grooved drums connected through trains of gears to motor or engine. Each drum contains and controls two operating ropes which pass, respectively, under and over deflecting sheaves at the corner of the span, thence one upward and one downward to connections on the lower column. Revolution in one direction winds on the up-haul ropes, pays off the down-haul ropes, and lifts the span; reversal of the drums pulls the span down.

The operating ropes connect to take-up devices and may be adjusted to have the same general tension at each corner. The span is thus moved, held level during operation, and may be held at any point or backed down by stopping the machinery. No other locks are necessary, although occasionally used, principally as part of a track-interlocking system.

Construction of Counterweights.—Methods of constructing counterweights vary with navigation conditions. When there is a closed season the lift span is placed on the piers, the suspending ropes connected and laid over the sheaves, the counterweight frames hung in place, wood forms bolted to them, and the concrete deposited. When the channel must be kept clear, the counterweights can be built in raised position on special beams attached to the towers or other falsework, the lift span floated in, or erected in elevated position, attached to the ropes and lowered to lift the counterweights so their supports may be removed.

Counterweights of pre-cast blocks can be erected with ordinary equipment without falsework, provided only that the channel may be blocked for the few hours needed to raise and place the counterweight parts. They can be taken down as readily, so this form is always used where various spans are made liftable, and is regarded with favour for any bridge.

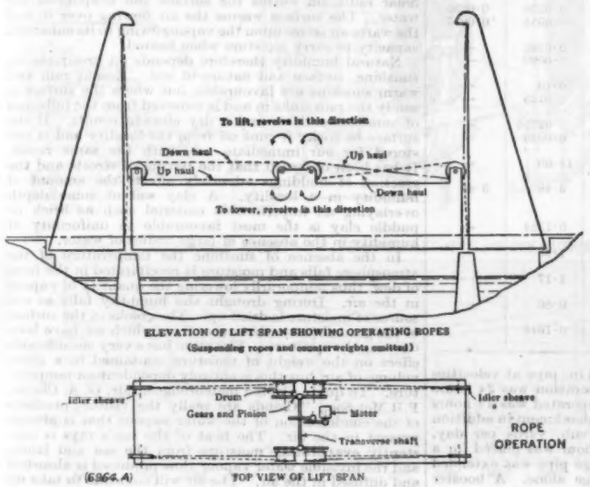


FIG. 1.

Except when the span and counterweights are at the same elevation, the suspending ropes are unbalanced. Ordinarily, this varying unbalanced load is handled by the surplus capacity of the operating machinery. Exact balance for all conditions may be secured with counterbalancing chains. Suspending sheaves may be used at the corners of a lift span effecting a three-part rigging of suspending ropes, reducing the counterweights by one-half, and doubling their height of movement. This was found advantageous with a very heavy span with low lift.

The counterweights are guided during movement by jaws engaging vertical tracks on the towers. The span is similarly guided, with allowances for temperature variation of span length, and for the deflection of the towers. At one end the span is held both laterally and longitudinally, at the other only laterally. To bring the span to exact lateral position for proper junction of track rails, the lower few feet of the guide tracks are battered out to take up all lateral clearance in the guides at the seated position of the span. The guide jaws may have rollers. Spring guides bearing on tracks on the faces of tower columns have been used, but are less satisfactory than the jaw guides.

The pier at the end of a lifting span supports, in addition to the loads of a fixed span, one tower, sheaves and ropes, one counterweight, and additional wind load. For a single-track railroad bridge, Class E. 55 loading, and lift span 200 ft. long for an ordinary inland river, this total extra load on one pier, except wind, is about 275 tons, which is additional to an ordinary imposed load for the fixed span of about 1,200 tons.

Near together over the Willamette River in Portland, Ore., serving the same kind of traffic, are one steam-operated swing span, one electrically-operated swing span, one excellent double-leaf bascule span, one double-deck lift span, and one simple lift span. County records show that the latter, the Hawthorne-avenue Bridge, serves more tonnage of traffic, operates more quickly, and costs less per operation than any of the others. Its openings average 15 daily, the average time that traffic is delayed per opening is 110 sec., the power consumption is less than 2 kw. per operation, and the cost of power per operation is about 5 cents. The lift span is 245 ft. long.

Many engineers for the owners of lift bridges and of the staffs of contractors and manufacturers have been identified with the design and construction of the bridges as listed in Table I. The development from 1909 to 1914 was principally by the firm of Waddell and Harrington, of which the writer was associate engineer, and since 1914 largely by the writer's present firm of Harrington, Howard and Ash.

PART II.—A BRIDGE WITH A LIFT SPAN.

The Columbia River Interstate Bridge.—The Columbia River Interstate Bridge, Figs. 2 and 3, with its approaches, extends across the valley of the Columbia River from Vancouver, Wash., to Portland, Ore., a distance of 3½ miles, and includes about 5,000 linear ft. of steel bridge structures and 12,000 linear ft. of embankment, in addition to which there is a secondary approach embankment on the Oregon side about 6,000 ft. long. The bridge and approaches provide a roadway for street traffic and tracks for street cars, and a sidewalk over the steel structures.

Clarke County, Washington, and Multnomah County, Oregon, built the structure with funds from issues of bonds, and operate it as a toll bridge. The construction cost was about 1,700,000 dols.; the gross receipts, beginning February, 1917, when it was opened to traffic, were about 300 dols. per day, but increased rapidly and for the past few years have approximated 300,000 dols. annually. Within a few years the counties will have retired the bonds and will own the structure unencumbered, acquired without any taxation. This is the only highway bridge across the Columbia River for a distance of more than 300 miles from the Pacific Ocean.

The Columbia River at this site has a maximum depth of 30 ft. The normal spring rise is 20 ft.; about once in four years it is 25 ft., and once it reached 33 ft. At extreme flood it covers the entire valley. The river bed is of sand, with some gravel, to great depths. Hard conglomerate—cemented gravel—is found near the surface of the north shore but drops rapidly to a depth of 100 ft. at 700 ft. from shore. Oregon Slough, a secondary channel separated from the main river by Hayden Island, is about 25 ft. deep, with a bed of sand to great depths. Columbia Slough provides some drainage near the north side of the valley, and is about 20 ft. deep. Hard material is found 80 ft. below water, overlaid with soft clay and sand. The average ground elevation over the valley is 12 ft. to 15 ft. above low water.

Over the Columbia River are three 275-ft. through-riveted truss spans with curved top chords, 10 similar spans 265 ft. long, and one small deck girder span, making a total length between end shoes of 3,531 ft. 6 in. The central of the three 275-ft. span is arranged to lift between towers on the other two, affording for navigation a channel 250 ft. wide, with a vertical clearance of 150 ft. at high water and 175 ft. at low water. No other movable span yet constructed with concrete floor and hard surface pavement provides so wide a channel.

Over Oregon Slough are 10 deck girder spans, 100 ft. long, and one similar span 115 ft. long, a total length of 1,137 ft. 6 in. There is now no navigation in Oregon Slough above the bridge site. The War Department permitted construction with all fixed spans, with the provision that one span should be convertible into a movable span. The 115-ft. span so converted, but constructing towers at each end, providing machinery, counterweights, &c., will afford a channel 100 ft. wide. This arrangement saved a present expenditure of about 30,000 dols., and added practically no cost to the present structure. Future construction will not interrupt traffic, and will not require any parts now built to be discarded. Over the Columbia Slough, there are four deck girder spans 75 ft. long. Future navigation can here be similarly accommodated.

The roadway over the steel spans and on Hayden Island is 38 ft. wide, on Union-avenue Approach 30 ft. wide, and on Derby-street Approach 24 ft. wide. The embankments are generally about 42 ft. wide and 24 ft. high, with 2 to 1 side slopes.

The structure is designed to carry 50-ton street cars, motor trucks of 24 tons maximum, roadway loads of 500 lb. to 800 lb. per linear ft. per line of traffic, and suitable sidewalk loads.

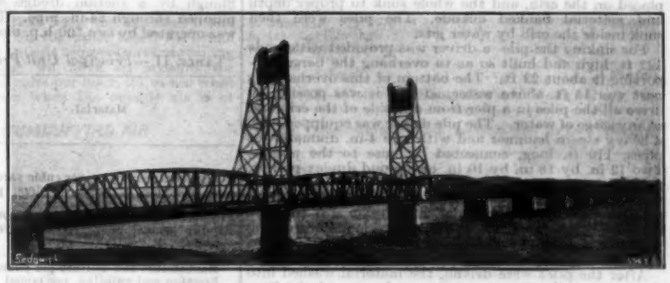


FIG. 2. COLUMBIA RIVER INTERSTATE BRIDGE: GENERAL VIEW FROM VANCOUVER END.

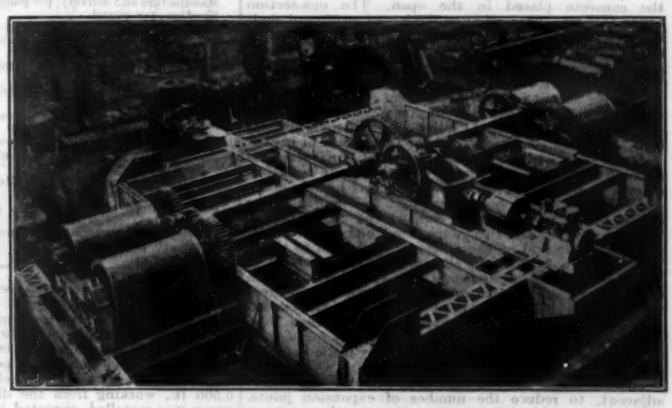


FIG. 3. OPERATING MACHINERY, COLUMBIA RIVER INTERSTATE BRIDGE.

Total Quantities.—The approximate quantities in the structure are as follows:—

Superstructure:	
Truss spans and girder spans	8,073 tons.
Towers and counterweights...	412 tons
Machinery and wire ropes ...	178 tons
Street-car rails and fastenings	440 tons
Roadway slab and pavement on spans	21,610 sq. yd.
Sidewalk slab...	3,250 sq. yd.
Substructure and miscellaneous:	
Volume of piers	28,050 cub. yd.
Piles below bases	133,500 lin. ft.
Reinforcing metal in piers...	70 tons
Rip-rap stone and rock fills...	23,300 cub. yd.
Embankment...	1,475,000 cub. yd.
Concrete slope protection on embankment	51,200 sq. yd.
Pavement base (broken stone)	16,875 cub. yd.
Bitulithic pavement on embankments	45,200 sq. yd.

The time of construction was two years.

Substructure.—The facility with which extremely long timber piles can be secured in this district at low price was a factor in the pier design. The river is subject to some scour, but soundings taken over many years disclosed no indications of scour to extreme or unusual depths at this site. The bases of the piers are of concrete enclosed by heavy timber cribs, and their bottoms are 20 ft. to 25 ft. below the river bed. They rest on piles which extend down about 110 ft. below low water, and up into the bases 15 ft. to 20 ft. The piles are thus thoroughly embedded in the concrete and form definite parts of the piers; they are single sticks about 120 ft.

long, 10-in. tip and 22-in. butt. There is an average of 1 pile to 10 sq. ft. of area, and in the ordinary pier under 265-ft. spans there are 90 piles. The total load per pile, dead and alive, is about 32 tons. Around each pier base there is heavy stone rip-rapping which will be replenished if necessary. Even though some unusual and extraordinary scour should extend below the bottom of its base, a pier would still be wholly stable because of the great penetration of the piles and the rigidity of their upper embedment.

The pier shafts are of concrete, each comprising a pair of cylindrical battered columns, joined by a vertical diagram and by a horizontal coping at the top, both reinforced. Large floes or sheets of ice in the Columbia River are rare and the concrete piers need no special protection of stone or steel facing.

The piers were built by excavating a hole in the river bed to full depth required, large enough for the sides to take a natural slope. A dipper dredge, of shovel type, with 4-yard bucket, was used and the excavated material taken by barge and used in embankments. The base crib was partly built on launching ways, floated to position and framed to full height. A removable coffer dam in one section, used successively on different piers, was then placed on the crib, and the whole sunk to proper depth and material banked outside. The piles were then sunk inside the crib by water jets.

For sinking the pile a driver was provided with leads 122 ft. high and built so as to overhang the barge supporting it about 22 ft. The bottom of this overhanging part was 15 ft. above water, so that it was possible to drive all the piles in a pier from one side of the crib and at any stage of water. The pile driver was equipped with a heavy steam hammer and with two 4-in. diameter jet pipes, 110 ft. long, connected by hose to the pumps. Two 12 in. by 18 in. by 10 in. compound duplex pumps, each with a capacity of 1,000 gallons per minute, were used for jetting. One four-drum and one two-drum engine handled the equipment, and steam was supplied from one 800-h.p. boiler. With jets and hammer working 10 minutes sufficed to sink a pile to full depth, and as many as 25 piles were sunk per day.

After the piles were driven, the material washed into the crib by the jetting was pumped out and the base filled by depositing concrete under water through a tremie up to within a few feet below water. The crib was later pumped out, the piles cut off, and the remainder of the concrete placed in the open. The one-section coffer-dam was lifted off after the lowest section of shaft had been concreted, and the rest of the shaft forms and concrete placed. The pier was then back-filled and rip-rapped.

Superstructure.—The trusses of the through spans are 41 ft., centre to centre, with the roadway between, and the sidewalk outside one truss. The floor is a reinforced concrete slab 5½ in. thick; the sidewalk also is of reinforced concrete. The floor arrangement is new. Between the usual floor beams are longitudinal stringers about 9 ft., centre to centre. On top of the stringers, extending across the roadway, are 8-in. I-beams, about 33 in. apart. These beams are bent to conform to the crown of the roadway, and support the concrete slab. The six rails for the two-gauge, double-track street-car tracks also are laid on these beams and bolted to them. The rails are 7 in. high, allowing depth for the 2-in. bitulithic pavement surfacing. A space about 5 in. wide on each side of each rail is filled with rich concrete for the full rail depth and, on the gauge side, forward for a flangeway. These concrete rail headings were compacted into place and the flangeways formed by rolling the plastic material with specially-made cast-iron wheels.

Two fixed ends and two expansion ends of the spans are adjacent, to reduce the number of expansion joints. The joints for the rails between spans are of manganese steel castings placed against the rail webs, for which one side of the railheads is planed off.

For the movable span, both a lift and a swing span were considered. Tentative approval was received from the War Department for a swing span affording two channels of 200 ft., and for a lift span for one channel of 250 ft., with vertical clearance 150 ft. above normal high water. Complete plans were made for both structures and bids received for both. The lowest bid for the bridge including the lift span was 70,000 dols. less than the lowest bid for the bridge with a swing span. The lift also causes least obstruction to river traffic. The main channel is close to the Vancouver shore and the necessary draw protection, about 500 ft. long for a swing span, would have been a serious detriment to the dock frontage adjacent to the bridge. No fenders have been found necessary with the lift span.

Arrangement of Machinery.—The arrangement of lift, towers and machinery is characteristic of the latest practice. One transverse shaft, one pair of gears in the frame inside the house, the back gears of the motors, the drums, gears and frames, and the corner deflecting sheaves make up the entire operating machinery (Fig. 3). There are two motors, and for emergency operation a 12-h.p. gasoline engine is connected through a speed reducer. The suspended load is 1,200 tons, and the total moving load 2,500 tons.

The counterweights may descend to within 2 ft. of the floor level, and to allow this movement the trolley wires under the counterweights are fastened to swinging frames which are pushed down by the counterweights and returned to position by small counterbalances. Manually operated roadway gates are located near the ends of the lift span, and operate derailing switches in the street-car tracks.

Erection.—Erection of the main river bridge was accomplished principally by floating from an erection and material yard in Vancouver, B.C. Each span in turn was erected parallel to the river on low falsework well back on the bank at the pier elevation. Timber trestles extended from it out into deep water, one at each end of the span, and constituted launching ways. After each span was completed and all rivets were driven, it was rolled out on the ways over deep water.

Four barges mounted by timber falsework were used to carry the spans to the piers. Variation of height for lifting and landing the spans was obtained by pumping water into and out of these barges. The lift span was floated to its position the same as the other spans. The span second beyond it was not placed until the towers and machinery had been installed and the lift span made operative, thus affording a channel for navigation. The towers were erected with a derrick on a wooden tower built on top of the lift span. The suspending ropes were attached to the lift span and laid over the sheaves and the counterweight frames suspended. Wood forms were bolted to these frames and the concrete elevated and placed in the high position of the counterweights. In due time the forms were removed, the operating ropes connected to the machinery, and the whole adjusted for operation.

Embankment Construction.—The approach embankments are of sand, principally dredged from Oregon Slough by a suction dredge with cutting head, and pumped through 24-in. pipe. The pump on the dredge was operated by two 500-h.p. motors, and was of capacity to give a discharge through the 24-in. pipe at velocities of 12 ft. to 15 ft. per second. Operation was 24 hours per day, and the actual net time operated was 14 hours per day, which was placed in the embankment in addition to wastage an average of 5,000 cub. yards per day. As much as 1,000 cub. yards per hour was placed for a few hours at a time. The discharge pipe was extended 5,500 ft., working from the dredge alone. A booster pump was installed, operated by one 1,000-h.p. motor, and the material handled through a total length of 9,000 ft. of pipe.

TABLE II.—*Principal Unit Prices Paid to Contractors.*

Material.	Main River Bridges.	Slough Bridges.
	dols.	dols.
Concrete in pier shafts, per cubic yard	9·00	10·00
Mass concrete in bases of piers, per cubic yard	12·00	11·00
Piles below pier bases, per linear foot	0·45	0·35
Rip-rap around piers, per cubic yard (solid)	2·05	2·00
Metal in truss and girder spans:		
Manufacture and delivery per pound	0·0259	0·0255
Erection and painting, per pound	0·0055	0·0055
Metal in towers:		
Manufacture and delivery, per pound	0·0343	—
Erection and painting, per pound	0·0090	—
Machinery and ropes:		
Manufacture and delivery, per pound	0·10	—
Erection, per pound	0·0125	—
Electric railway rails and fastenings:		
Manufacture and delivery, per pound	0·02755	—
Erection, per pound	0·0040	—
Concrete in counterweights, per cubic yard	14·00	—
Concrete roadway, slabs, and bitulithic paving, per square yard	3·48	3·48
Hayden Island and Union Avenue Approach:		
Embankment in place, per cubic yard	0·1324	—
Broken stone paving base, per cubic yard (loose)	1·48	—
Bitulithic paving on broken stone base, per square yard	1·17	—
Concrete slope protection slabs, per yard	0·80	—
Derby-street Approach embankment in place, per cubic yard	0·1648	—

The embankment was formed with longitudinal timber bulkheads, which were of 6-in. by 8-in. posts, about 10 ft., centre to centre, sheathed with 2-in. planks for a height of 5 ft. The embankment sides were thus built up in steps of 4 ft. high and 8 ft. wide. The posts were tied back to stakes fronted by planks. The pipe extended longitudinally along the centre line of the embankment from the river so as to bring the embankment up to final grade and working away from the dredge. It discharged on a frame of baffle-boards spreading the water and depositing the sand. The bulkhead planks were removed and re-used and the embankment sides finished to an even 2 to 1 slope. The embankments were finished by fortifising and planting the sides with grass and indigenous shrubs, including about 4,000 Scotch broom plants and 2,000 rose bushes. The pavements are bitulithic on a broken-stone base.

At each end of the main river bridge there are two entrance columns or pylons of concrete, together with short lengths of ornamental concrete hand rail. At the Vancouver end a small drinking fountain is included. These pylons bear bronze tablets giving the names of those associated with the work, with summaries of quantities and costs, and also inscriptions representing something of the purpose and ideals of those responsible for the bridge.

Costs.—The total cost of the entire structure and of the principal separate portions follows:—

	Dols.
Columbia River Bridge	891,005·45
Oregon Slough Bridge	196,944·47
Columbia Slough Bridge	74,942·99
Vancouver Approaches	16,086·87
Union-avenue approach	251,220·26
Derby-street Approach	104,877·76
Lighting system	16,014·05
Ferry landings	16,890·24
Tracks on Vancouver streets	7,139·99
Right of way	25,449·63
Fees to engineers	80,000·00
Miscellaneous	2,984·61
Total	1,683,556·32

In Table II the principal unit prices paid to contractors are listed.

(To be continued.)

THE VENTILATION AND HUMIDIFICATION OF TEXTILE FACTORIES.*

By H. N. LEASK, A.M.Inst.C.E., M.I.E.S.

HOWEVER favourable a particular climate, such as Lancashire, may be for carrying on textile industries profitably, daily and seasonable variations leave much to be desired. Natural variations are intensified inside the factory by the employment of machinery, &c. Lack of constancy inside the factory is prejudicial to maximum production and welfare of the operatives, but the desired constancy can be readily and simply obtained within reasonable limits. Suitable plant must be installed to effect this and must be intelligently operated. Such plant is not a luxury, but a prime necessity, if maximum output at reduced cost is sought.

The business of the engineer is to utilise and control the forces of Nature for the use and benefit of men. This involves a study of what takes place in Nature. There seems to be an impression abroad that the humidity of our atmosphere is caused by the absorption of moisture from rain in the act of precipitation; this is not the fact—or, at least, is only partly so. Let us examine for a moment how the atmosphere is, in fact, humidified. Rain is precipitated from time to time on the surface of land and sea. If the atmosphere is hot enough, it is partly evaporated during its passage. Having reached the surface, it is stored if the ground is favourable. Solar radiation warms the surface and evaporates the water. The surface warms the air flowing over it and the warm air seizes upon the vapour owing to its enhanced capacity to carry moisture when heated.

Natural humidity therefore depends on precipitation, sunshine, surface and nature of soil. Recent rain and warm sunshine are favourable, but where the surface is sandy the rain sinks in and is removed from the influence of sunshine and air and a dry climate results. If the surface be rocky it runs off from the locality and is not stored for our immediate use, with the same result. It has been observed that the paving of streets and the erection of buildings adversely affects the amount of humidity in a locality. A clay soil of some depth overlaying an impermeable material such as brick or puddle clay is the most favourable to uniformity of humidity in the absence of large bodies of water.

In the absence of sunshine the temperature of the atmosphere falls and moisture is precipitated in the form of dew, thus temporarily lowering the quantity of vapour in the air. During drought the humidity falls as our source of moisture is dried up. The cracks in the surface of the ground prove the source from which we have been drawing the moisture. Elevation has a very considerable effect on the weight of moisture contained in a given volume of air, but this is entirely dependent on temperature. To quote a noted meteorologist, Mr. G. A. Clarke, F.R.Met.Soc., "Clouds are really the visible products of the condensation of the water vapour that is always present in the air. The heat of the sun's rays is constantly evaporating moisture from the sea and lands, and the invisible water vapour thus produced is absorbed and diffused in the air. The air will continue to take up water vapour and the latter will remain invisible until a point is reached when the air becomes saturated, and then any further addition of water vapour results in super-saturation, and the excess of moisture becomes visible as a cloud provided there are present in the air nuclei upon which condensation can form."

At a height of 3 miles air can contain only one-fifth of the vapour of that at the earth's surface, and at 6 miles only one-thirtieth of the surface quantity. This is because the temperature falls with the elevation at the average rate of 3½ deg. F. per 1,000 ft. Evidence of this phenomenon is to be found in our skies daily. The heavy low-lying clouds accompanying bad wet weather are nearer the surface than the light feathery clouds seen in fine weather.

To come to our conditions, air at 10 deg. F. contains when saturated 0·8 grains vapour per cubic foot, at 32 deg. F., 2 grains; at 66 deg. F., 7 grains; and at 100 deg. F., 19·8 grains. Saturation is simply a state of equilibrium. If we pass this point moisture is condensed, but it is of great importance to note that we can have super-saturation, a state which is not disclosed by the wet and dry thermometers. This state can be reproduced artificially with certain apparatus. When saturated air is heated the relative humidity falls. When cooled, condensation takes place, but the relative humidity remains approximately the same. It follows that when we cool unsaturated air we increase the relative humidity until the dew point or point of saturation is reached.

We can now see that constancy of humidity depends upon availability of a water supply, a source of heat and means of regulating the temperature. Ventilation depends upon movement, and unequal heating causes differences of pressure in the atmosphere, producing a current of air or wind. The wind is another great source of keeping the earth's surface cool and comfortable.

* Abstract of paper read before the Rochdale Cotton Spinners' Mutual Improvement Society.

and probably does a larger share of this work than the evaporation of rain. If we are to copy nature and complete our requirements for constancy, we must have the means of moving air.

Apart from the causes of daily and seasonal changes above described, when we introduce air into a factory we have another set of causes, though all of one nature, namely, heat from the following sources: (1) Power supplied to the machinery converted into heat and liberated; (2) the heat given up by the surfaces of steam pipes, if present; (3) bodily heat given up by the operatives; (4) solar heat entering the building *via* the roof and walls; (5) heat from internal lighting; (6) incidental sources of heat, such as proximity to a boiler-house.

Of all these, the most important in the spinning and weaving of cotton is (1). This source of heat cannot be eliminated, and can only be reduced by having machines of higher mechanical efficiency than those in general use. In any case it is only in very hot weather that this heat presents any difficulty in obtaining the desired constancy. (2) This source of heat can be eliminated. (3) This can only be reduced by reduction in the number of operatives. (4) Can be reduced by whitewashing and/or spraying the roofs. (5) This only occurs at certain seasons, and unless night work is carried on in hot weather does not complicate matters. (6) If present must be taken care of.

Knowing the sources of heat we can calculate with some accuracy the magnitude and effect of the liberated heat. Take as an example a weaving shed for which

Fig. 1. HUMIDIFYING INSTALLATION FOR CLEANSING, TEMPERING, & HUMIDIFYING AIR.

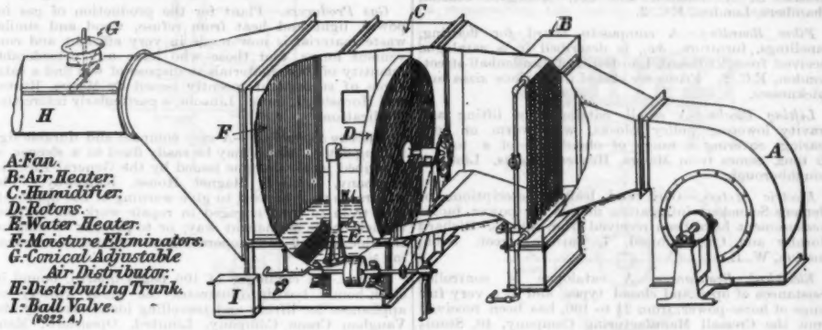
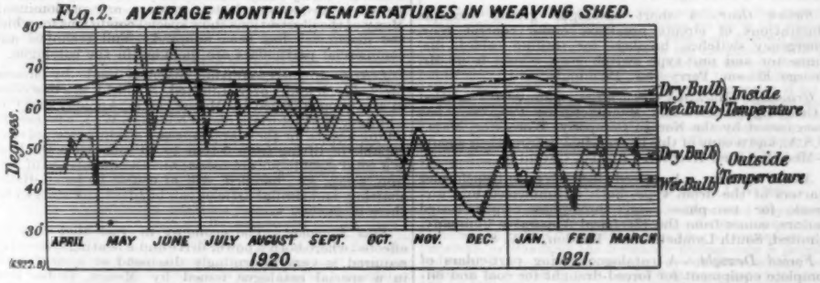


Fig. 2. AVERAGE MONTHLY TEMPERATURES IN WEAVING SHED.



representative temperatures can be given for a period of twelve months. The shed is 400 ft. long, 156 ft. wide, 15 ft. average height. Cubic capacity, 925,000 cub. ft. It contains 1,456 looms. There are about 500 operatives. There are no steam pipes, and the aspect is northerly.

(1) Now as 1 h.p. = 2,540 British thermal units per hour, and each loom takes about one-third of 1 h.p. to drive, the amount of heat generated = $\frac{1,456 \times 2,540}{3}$. Equals, say, per hour, 1,230,000 British thermal units.

(3) The bodily heat given off by an operative varies according to some authorities from 300 British thermal units to 900 British thermal units per hour. For the purpose of our calculations we take 500 British thermal units. Now, as a number of operatives is about 500, the amount of heat liberated = 500 × 500 per hour = 250,000 British thermal units.

(4) This cannot be computed with any certainty, but we know from the observation of others that the difference of temperature inside a shed between a sunny and a cloudy day is some 6 deg. F. at the end of the day. Taking an average of 3 deg. F., and assuming that the air was moved once per hour, we arrive at the following figures:

$$\frac{925,000}{13} \times 0{\cdot}25 \times 3 = 54,000 \text{ B.T.U. per hour.}$$

These three items make a total of 1,534,000 British thermal units per hour. Where the outside air is of higher temperature than that of the shed we should have to add considerably to this figure. We will deal with such a case later. Let us pause for a moment and consider the magnitude of these figures.

The amount of heat required to raise the temperature of the shed 1 deg. in 1 hour with still air equals:

$$\frac{925,000}{13} \times 0{\cdot}25 = 18,000 \text{ B.T.U.}$$

Therefore if the heat were given to the air there is sufficient to raise the temperature of the shed some 85 deg. F. in 1 hour. But we know that this does not happen. Fortunately there are several factors operating to prevent such a catastrophe. First, the work converted into heat (1) is stored in the mass of machinery, &c., and is not liberated until the temperature of the machinery, &c., is higher than that of the air in the shed. For instance, for every 100 tons of machinery and iron work in the shed and for each 5 deg. F. rise in temperature, about 130,000 British thermal units would be stored. Practical experience goes to show that it is safe to assume that some 50 per cent. of heat from work is stored in the machinery, building and contents. Second, when the temperature of the room is above that of the outside air some of the heat is dissipated through the walls, floors and roof. This varies from 40 British thermal units to 50 British thermal units per hour per 1 deg. difference of temperature per 1,000 cub. ft. of shed, or in the case we have under examination, 40 × 925 to 50 × 925 equals 36,100 British thermal units to 46,250 British thermal units per hour per degree of difference.

If the shed were run day and night complications would ensue, as we would have to reckon on removing nearly the whole of the heat from the machinery and the heat from lighting. On the other hand, we would be favoured by the lower outside temperatures prevailing at night. Assuming that we have to account for 1,534,000 British thermal units per hour, let us see what residues of heat there are when the outside air is at 30 deg., 48 deg., 60 deg., 70 deg. and 80 deg. F., respectively, and the inside air is at 70 deg. F. The accompanying tables give these figures.

Referring to Table III with outside temperature at 30 deg. F. and inside 70 deg. F., this shows a deficiency of 616,000 British thermal units per hour, and it would, as we all know, be necessary to artificially heat the shed both in the morning and throughout the day. Our humidity would also be very deficient. To increase the humidity we must evaporate water, requiring further heat. The total quantity would depend on the number of times the air in the shed was changed. When the outside temperature is 48 deg. F. and the inside 70 deg. F. we have a surplus to be removed, provided we have heated up the incoming air, and we have also to regulate the humidity as before, but requiring a small expenditure of heat. When the outside temperature is 80 deg. F. and the inside 70 deg. F. we have a formidable surplus to be removed per hour, namely, 1,259,000 British thermal units.

With the aid of these tables we may now proceed to arrive at the total heat involved for each time the air is changed per hour under the varying outside conditions. Table IV. shows the amount of heat to be added or removed for the first change per hour.

Referring to Table IV, we see when the outside air is 60 deg. and inside 70 deg. F., that in order to prevent a rise in temperature of the air in the shed it must be changed more than once per hour. Again, when the outside temperature is 70 deg. F. and the inside is 70 deg. F. we have a surplus of 884,000 British thermal units to be removed hourly. If we assume that the outside air is about right as to humidity, it becomes a simple problem of the number of times we must move the air per hour to carry off this amount of heat without an appreciable rise in temperature. To effect this we must cool the air to keep our humidity right. We cannot without special provision for super-saturation cool below 67 deg. F. This gives us a difference of 3 deg. F. To effect our purpose we would have to move the air 15·5 times per hour. If a rise of 8 deg. is permitted, then six times per hour; so as to bring the movement within reasonable limits we must foresee some rise in temperature or more cooling coupled with super-saturation.

Suppose we cool air to 65 deg. F. dry bulb, 63 deg. F. wet, and permit a rise to 75 deg. F., and super-saturate 1·6 grains, we should then have to change the air only 4½ times per hour to prevent temperature rise. When the air is at 80 deg. F. we have the same problem intensified. Suppose we can cool to 65 deg. and permit a rise to 75 deg., and that we can super-saturate with 1·6 grains as above, then we need change the air 6½ times to prevent temperature rise.

A spinning room is a similar problem to that just investigated, with certain important exceptions. Namely, that a spinning room is generally much smaller than

TABLE I.—*Inflowing Heat.*

	B.Th.U. per Hour.
1. From power supply	1,230,000
2. Steam pipes	nil
3. Operatives	250,000
4. Sunshine	54,000
5. Internal lighting	nil
6. Incidental causes	nil
Total	1,534,000

TABLE II.—*Outgoing Heat, through Walls, Roofs, &c.*

Outside Temperature.	Inside Temperature.	B.Th.U. per Hour.
Deg. F.	Deg. F.	
30	70	+ 1,500,000
48	70	+ 810,000
60	70	+ 375,000
70	70	nil
80	70	− 375,000

* This heat is flowing in, hence the − sign.

TABLE III.—*Net Residues of Heat.*

Outside Temperature.	Inside Temperature.	B.Th.U.
Deg. F.	Deg. F.	
30	70	− 616,000
48	70	+ 74,000
60	70	+ 509,000
70	70	+ 884,000
80	70	+ 1,259,000

TABLE IV.

Temperatures.		Heat to Raise Temperature Air to 70 Deg. F.	Heat to Evaporate Required Moisture.	Residual Heat (Assuming one movement per Hour).	Total Heat (i.e., Net Deficiency per Hour to be made up.
Outside.	Inside.	B.Th.Us. per Hour.	B.Th.Us. per Hour.		B.Th.Us. per Hour.
30	70	621,070	711,539	616,000	1,948,609
48	70	488,400	396,000	74,000	810,400
60	70	264,000	180,000	590,000	65,000*
70	70	Assume outside conditions correct for inside weaving		884,000	884,000*
80	70	Cooling effect required		1,259,000	1,259,000*

* Net surplus to be removed.

the weaving shed we have described. The horse-power per unit of space is much greater and the losses through the floor much less. This problem is simpler of solution as higher temperatures are preferred and allowed, and the degree of humidity is much less.

There is no difficulty in maintaining inside conditions of: 80 deg. and 69 deg. F. wet bulb; 86 deg. and 74 deg. F. wet bulb; 90 deg. and 77 deg. F. wet bulb, through the year. It is simply a question of introducing the right volume of air at the correct degree of humidity.

From the above it is quite clear that to prevent excessive rise of temperature in a shed we are compelled to move the air. There is no other solution in the summer time. Further, we have seen that in the winter time we must introduce large quantities of heat, and this is most easily and economically done by moving the air and causing it to traverse central heating points. It must be borne in mind that the above calculations are characteristic of what is occurring in a shed, and the figures given are approximate only. This applies more especially to the quantity of heat stored or liberated.

Ventilation.—We have demonstrated that we must ventilate vigorously over the greater part of a year. In a large shed already constructed this can only be effected by introducing and distributing the air by means of ducts if all the looms and operatives are to receive the benefit of like air. Furthermore, to avoid draughts and to obtain equal distribution the exits must be very small, numerous and evenly distributed. Various objections are raised to the use of ducts in the roof, namely, interference with light, as collectors of dust, cost of upkeep and first cost. When skill is employed in locating the ducts and they are painted white and round in section, the first objection is not a serious one. As to the second, it is true dust will collect

on the ducts, as it will elsewhere and must be removed, but objectionable falls of dust due to sliding of accumulation can be avoided with suitable construction.

As regards upkeep of the ducts. No moisture is deposited therein as long as the shed is at a higher temperature than the incoming air. When cooled at night below the dew point or at times when the air is supersaturated, some moisture may be deposited and to avoid it collecting, the ducts should be sloped and drained at the end. It must be remembered that when the air is super-saturated there is a large surplus of heat tending to keep the shed warmer than the incoming air. Ducts are admittedly a costly item to install, but they must be regarded as a necessary evil unless a series of small units are installed in various parts of the shed. In a new shed various other methods can be adopted, such as utilising the roof columns connected to ducts in the floor. The introduction of such large volumes of air at all seasons raises another important point, namely, the cleaning of the air. Hitherto various forms of filters have been used and have failed chiefly because they quickly become clogged up with dirt, not being self-cleansing in action. Now, however, a self-cleaning and fool-proof filter is on the market, and no trouble is experienced with smuts, dust or smoke.

Having now more or less fully described the problem which faces us and how it may be solved, it remains to describe an apparatus designed by Mr. A. B. Cleworth to meet all the requirements of constancy of humidity and ventilation, &c., He set out to achieve the following objects: (1) To attain a uniform condition of the atmosphere in the factory from hour to hour and day to day independent of the outside conditions. (2) To provide an atmosphere containing moisture in an aeriform or invisible state as in nature. (3) To give uniform conditions over large areas and in all parts of a room or shed. (4) To supply clean air free from dirt, soot or fog, at a uniform temperature. (5) To efficiently ventilate without causing draughts. (6) To comply with the Factory and Workshops Acts, 1908–11. (7) To attain these objects with simplicity of construction, operation and control, with minimum first cost and upkeep.

Apparatus.—The elements which, combined, form the complete system, are shown on Fig. 1, and consist of: (A) Centrifugal cased fan capable of regulation as to quantity of air handled within wide limits. (B) Air heater for heating or tempering the air entering the mill, fitted with valves for regulating the temperature of the air within wide limits, depending upon local conditions and particular applications. (C) Humidifier casing and water storage tank. (D) A plurality of rotors consisting of a series of discs of fine mesh-expanded metal spaced at suitable distances apart along the same axis and so staggered as to cause the air to zig-zag in its passage through the machine. The discs are submerged in water in the lower part of the casing for a few inches only, the level being maintained by means of a ball-valve. A number of discs are nested together to form a rotor. They are built on spiders and enclosed in a stout outer rim. The rim makes a running joint against the air baffle, which prevents the leakage of any unhumidified air past the rotors. The rotors are mounted on a shaft which revolves at a slow rate and receives its motion either through enclosed gearing or chain. As the rotors pass through the water they automatically pick up sufficient to wet and cleanse each of the discs thoroughly and to deposit any solid impurities in the tank. The first rotor acts as a filter, the additional rotors make up the wet surfaces from which the air takes up moisture by evaporation. (E) Water heater for tempering the water in the storage tank, fitted with valves for regulating the temperature. (F) Eliminators for intercepting any suspended moisture entrained in the air leaving the rotors. (G) One of a number of distributing valves placed at intervals in the distributing trunk. (H) Distributing trunk which carries the air to the various parts of the mill. (I) Ball valve for maintaining the water level in the storage tank.

When we require to heat the mill or shed we open out the steam coils. If we require to cool the incoming air we circulate cold water through the tank. Flexibility with ease of regulation is the special claim made for the apparatus. The diagram Fig. 2 shows by curves the average monthly dry and wet bulb temperatures in an important weaving shed and corresponding outside temperatures over a period of twelve months. Outside temperature varied from 34 deg. to 78 deg. F. The maximum inside variation between 11 a.m. and 8 p.m. was 4 deg. F. The average outside was 20 deg. F. The variation in length of 400 ft. was about 2 deg., partly accounted for by proximity of air hygrometers to an outside wall. Average variation over twelve months, 7 deg. F. The shed was worked cool by desire, but it may be said in closing that with closer regulation still greater uniformity could have been obtained had it been desired. It is understood that production per hour has been considerably increased and there have not been any complaints from the operatives, no matter where placed.

British Industries Fair, Birmingham, 1922.—The Birmingham authorities are now issuing a prospectus dealing with the fair which is to be held in their city from February 27 to March 10, 1922. The schedule of exhibits has been widened, new groups being included for the following trades: Construction building and decoration; agricultural; mining; brewing, distilling and catering services. In addition the existing groups of metals; power, lighting and heating; engineering; hardware, brassfoundry and ironmongery, have been enlarged, and now become thoroughly comprehensive of the manufactures embraced by the respective titles. Further information can be obtained from the British Industries Fair (Birmingham) Incorporated, Chamber of Commerce, 95, New-street, Birmingham.

CATALOGUES.

Valves.—Small valves from ¼ in. to 2 in., of the usual screw-down non-return types, are described in a catalogue from the Lunkenheimer Company, Cincinatti, U.S.A.

Wire.—A vest pocket size booklet containing useful data on wires of all usual materials, comes from Messrs. W. F. Dennis, 70, Queen Victoria-street, London, E.C. 4.

Lubrication of Leaf Springs.—A descriptive pamphlet of their grease retaining cover for leaf springs had been issued by Messrs. Brown Brothers, Limited, Great Eastern-street, London, E C. 2.

Optical Instruments.—An abridged catalogue and a copy of their monthly price list of optical instruments has been received from Messrs. Adam Hilger, Limited, 75a, Camden-road, London, N.W. 1.

Hack Saw Guides.—A guide for a hand-operated hack saw, swinging from a pedestal fixed to the bench, is described in a catalogue received from the makers, Hacksaws, Limited, Capel-street, Sheffield.

Second-Hand Machinery.—A very extensive list of second-hand and rebuilt machine tools and another list of wood-working machines, have been received from Messrs. Haighs (Oldham), Limited, Oldham.

Oxy-Acetylene Welding.—A new list of gas generators, blow pipes, for welding and cutting, portable complete outfits, and general supplies, comes from the Davis-Bournonville Company, Jersey City, N.J., U.S.A.

Steel Beams.—A little booklet setting forth the advantages of their broad flange beams has been issued by Messrs. R. A. Skelton and Co., Moorgate Station Chambers, London, E.C. 2.

Fibre Boarding.—A composite board for flooring, panellings, furniture, &c., is described in a catalogue received from Vi-Board, Limited, 149, Leadenhall-street, London, E.C. 2. Prices are stated for various sizes and thicknesses.

Lifting Blocks.—A small catalogue of lifting and gravity lowering pulley blocks, with worm or spur gearing, covering a range of one-eighth of a ton to 20 tons, comes from Messrs. Herbert Morris, Limited, Loughborough.

Electric Meters.—Card and leaflet descriptions of Siemens-Schuckert integrating meters for power factor measurement have been received from Messrs. Richard Hornby and Co., Limited, 7, Carlisle street, Soho, London, W. 1.

Electrical Resistances.—A catalogue of controller resistances of open and closed types, and in a very full range of horse-power, from 2½ to 100, has been received from the Cressall Manufacturing Company, 40, Stanifforth-street, Birmingham.

Switch Gear.—A short catalogue giving example illustrations of circuit breakers, crane control gear, emergency switches, breakers for trailing cables, disconnector and unit-type switch gear, comes from Mr. George Ellison, Perry Bar, Birmingham.

Grinding Machines.—A large pamphlet entitled "Grinding Practice and Manufacturing Progress," has been issued by the Norton Company, Worcester, Mass., U.S.A., and a copy of this has reached us from their agents —Messrs. Alfred Herbert, Limited, Coventry.

Motor Starters.—A priced list of auto-transformer starters of the drum type, both oil immersed and air-break for two-phase and three-phase squirrel-cage motors, comes from the Electrical Apparatus Company, Limited, South Lambeth-road, London, S.W. 8.

Forced Draught.—A catalogue giving particulars of complete equipment for forced-draught for coal and oil-fired boilers, with illustrations of a number of vessels fitted with their system, comes from Messrs. John Reid (London), Limited, 4, Lloyd's-avenue, London, E.C. 3.

Hard Rubber.—An extremely useful little booklet on the use of hard rubber material as a lining or covering, and also in complete parts, has been issued by Hightensite, Limited, Custom House, London, E. The material is supplied in rods, sheets, tubes and moulded forms.

Hauling Engines.—A catalogue of hauling engines with drums mounted on steel plate frames, and mainly used in collieries, comes from Messrs. John Mills and Co., Llanydloes, Mont. All parts are made to standards, and a list for ordering replacements is included in the catalogue.

Electric Lifts.—A catalogue of passenger and other lifts issued by Messrs. Etchells, Congdon and Muir, Limited, 15, Cannel-street, Ancoats, Manchester, pays special attention to safety devices. This firm provides the entire equipment for lifts, which appear to be of neat and substantial design.

Aluminium Power Transmission Lines.—A few neatly printed pages of pocket-book size, giving practical information about the qualities and methods of fitting overhead lines of hard-drawn aluminium, comes from the British Aluminium Company, Limited, 109, Queen Victoria-street, London, E.C. 4.

Grinding Machines.—A hand machine for grinding or polishing and several small machines for fixing to a bench are described in a leaflet received from the Consolidated Pneumatic Tool Company, Limited, 170, Piccadilly, London, W. 1. All are driven by small electric motors embodied in the frame.

Hauling Machines.—Two catalogues, one dealing with electric haulage gears and the other with similar appliances driven by steam and compressed air have reached us from the Uskside Engineering Company, Limited, Newport, Mon. The sizes are suitable for the general range of colliery and similar service.

Shaft Couplings.—A flexible shaft coupling which allows for slight errors of alignment such as occur from wear of bearings and other causes, and also absorbs torsional shocks is clearly described in a booklet issued by the Wellman-Bibby Company, 36, Kingsway, London, W.C. The coupling is compact, and has no projecting parts.

Gauges and Chasers.—A number of leaflets describing plug and ring-screw gauges, adjustable snap gauges for measuring threads, limit gauges of the usual form, slip gauges, a bench gauge with fluid pressure indicating and amplifying device, and gapped circular chaser tools for screw cutting have been received from Messrs. Alfred Herbert, Limited, Coventry.

Steel Castings.—Steel castings of intricate shapes and in metal which may be forged, twisted or bent, are described in an informing little booklet issued by Messrs. Holcrofts Steel Foundry Company, Limited, 329, High Holborn, London, W.C. 1. The patterns are made at the foundry, in Bilston, Staffordshire, and several grades of steel and processes are available.

Electric Arc Welding.—The machinery and general equipment, stationary and portable, for welding and cutting by electric arc, form the subject of a special catalogue issued by the Metropolitan Vickers Electrical Company, Limited, Trafford Park, Manchester. The practical information on the process and examples of work illustrated will be interesting to those engaged in this class of work.

Gas Producers.—Plant for the production of gas for power, light and heat from refuse, wood and similar waste material is now made in very efficient and convenient forms, and those who have any considerable quantity of these materials to dispose of will find a catalogue of such plant recently issued by Messrs. Ruston and Hornsby, Limited, Lincoln, a particularly interesting publication.

Railway Signalling.—A very compact and durable signalling device, which may be easily fixed to a sleeper, is described in a catalogue issued by the General Electric Company, Limited, Magnet House, Kingsway. The apparatus may be used to give warning of the approach of a train to men engaged in repair work on bridges, tunnels or the permanent way, or to persons walking on the line, as well as for operating station and other warning signals.

Cranes.—A catalogue of 100 pages quarto, bound in cloth-bound boards, illustrates the great variety of appliances for lifting and travelling loads made by the Vaughan Crane Company, Limited, Openshaw, Manchester. Many of these are operated by hand, but where power is necessary electric motors are predominant. Many of the illustrations show special conditions for which the machinery has been adapted. Full technical and commercial particulars are included in the catalogue.

Lifting Magnets.—Lifting magnets made by Messrs. Steel, Peech and Tozer, Limited, Sheffield, are described in a catalogue issued by Messrs. E. G. Appleby and Co., Limited, 70, Victoria-street, London, S.W. 1, who are the selling agents for these appliances. Eight principal sizes capable of lifting from 5 tons to 40 tons when the load is a solid steel ingot are listed, but the quantities of pig-iron, scrap, &c., handled, will of course be less. Rails, shafting, and similar articles can be lifted and stacked by these magnets.

Fuel Economy.—The economy in fuel that may be effected where both a power drive and a heating system are required is very informingly discussed at some length in a special catalogue issued by Messrs. Belliss and Morcom, Limited, Birmingham. Under certain conditions remarkable results can be obtained, and substantial economies are possible in a great many cases. It is now more than ever necessary that owners of factories or any fairly large works or buildings should seek the advice of engineers on the whole scheme of power, light and heat.

Cost of Preparing Pulverised Coal.—During 1920, according to *Power*, of New York, the cost per ton of preparing coal in the power plant of the Clarkdale smelter was as follows:—

	Dols.
Unloading, storing and reclaiming coal...	0·07
Conveying and primary crushing ...	0·09
Drying and disintegrating	0·30
Pulverising	0·52
Total operating costs	0·98

These figures include power, labour, supplies, repairs and plant expense, but do not include depreciation and other fixed charges. The installation costs of a pulverising plant are as follow—

	Dols.
Storage and reclaiming plant, per ton storage capacity	13
Primary crushing plant, per ton daily capacity	32
Drying and disintegrating plant, per ton daily capacity	286
Pulverising plant, per ton daily capacity	402

For a 300-ton plant, with a seven-day storage capacity, the investment would be about 243,000 dols.; interest, depreciation and taxes assumed to equal 15 per cent., give 0·33 dol. per ton, making the total pulverising cost 1·31 dols. per ton.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

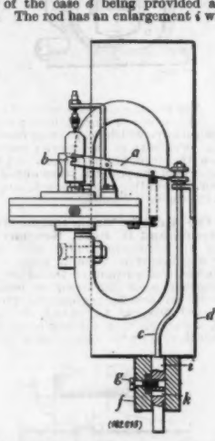
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

ELECTRICAL APPARATUS.

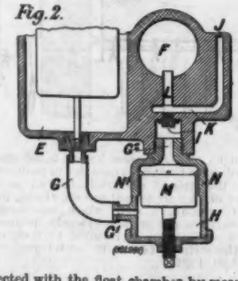
162,015. Chamberlain and Hookham, Limited, Birmingham, and S. James, Birmingham. Electricity Meters. (1 *Fig.*) November 20, 1919.—This device provides for the automatic actuation of the sealing of the mercury bath of electricity meters of the mercury motor type during transport, or when the meters are taken down from their normal service positions, a spring-controlled lever *a* and a rod *c* passing from the interior to the exterior of the case *d* being provided adjacent to the usual terminals. The rod has an enlargement *i* with a transverse



aperture *k* and is held in the position shown by a screw *g* which engages the aperture *k* and also serves to hold in place a detachable cover *f* for the terminals. Before the screw *g* is inserted for securing the cover *f*, the rod *c* is pushed in for releasing the sealing mechanism *b*. When it is desired to take down the meter it is first necessary to detach the leads from the terminals. For this purpose, the terminal cover *f* is removed, and the withdrawal of the screw *g* releases the rod *c*, permitting the sealing mechanism *b* to be brought into action automatically by the spring which acts on and moves the lever *a*. (*Sealed.*)

GAS ENGINES, PRODUCERS, HOLDERS, &c.

161,991. H. Fowler, South Farnborough, and A. L. Bird, South Farnborough. Carburettors. (2 *Figs.*) September 24, 1917.—In a carburettor for aero engines of the kind in which there is provided instead of or in conjunction with the fuel jet an arrangement providing a restricted passage through which the fuel is constrained to pass on its way to the engine, there is arranged a length of coiled pipe D of fine bore in comparison with its length, through which the fuel is made to pass, so that the flow of fluid is proportional to the head producing the flow. A is the float chamber in which the fuel is maintained at constant level, B a tube through which the air for combustion is drawn by the suction of the engine, and C is the fuel

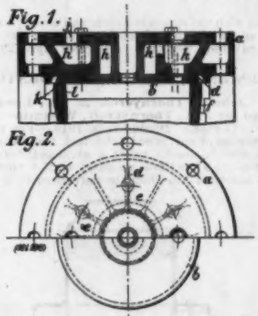


orifice connected with the float chamber by means of the small bore pipe D which consists of a length of tube coiled into a helix. The application of the invention to a carburettor of the type in which the fuel regulating orifice is normally submerged, and a small quantity of air is allowed to mix with the fuel between the orifice and the induction pipe of the engine is illustrated in Fig. 2. E is the float chamber in which the fuel is maintained at a constant level, and F is the induction pipe of the engine. G, G1, G2 are passages for conveying the fuel, while H is a chamber arranged with a restricted passage between M, N. I is in normal carburettors the fuel orifice, which, in the present case, is enlarged in bore so as to be of negligible resistance. J is an air orifice leading to a chamber K wherein the fuel from I, and the air entering at J, are mixed before issuing to the induction pipe F through the passage L. In this design, the constriction of the passage is arranged for by a cylinder M surrounded by a hollow cylinder N, so that there is a very narrow annular space N1 left between them through which the fuel is constrained to pass from the float chamber on its way to the induction pipe. (*Sealed.*)

161,999. C. Brown, Birmingham, and Brown and Barlow, Limited, Birmingham. Carburettors. (1 *Fig.*) September 13, 1919.—In the manufacture of a carburettor having a longitudinally-sliding throttle valve *c*, a liner *b* of brass, steel, or other tubing is cast in in the process of casting the body

a of the carburettor, and forms a bearing for the longitudinally-sliding throttle valve. The brass, steel or other tubing is of rectangular cross-section. The valve *c* is in the form of a plate and is capable of being moved across the straight-through passage constituting the main air conduit of the carburettor. (*Sealed.*)

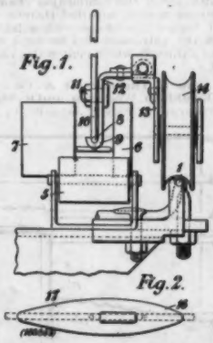
161,198. C. J. Hawkes, London. Cylinder Covers. (4 *Figs.*) April 11, 1919.—A cylinder cover of an internal combustion engine consists of two independent members, one of which, *a*, constitutes an outer or strength member, and supports against the working pressure, through the medium of numerous shallow webs or ribs *d*, depending therefrom, the other or inner member *b* consisting of a thin plate located in the combustion zone. The webs or ribs *d* on the outer member *a* form between the two members *a* and *b* a series of ducts *e*, through which cooling water can flow. As the inner member *b* is reinforced by the outer member *a* the former can be made from a comparatively thin casting or forging; consequently the



cooling of this member during the operation of the engine is facilitated and the temperature stresses set up in the material are appreciably reduced. The ribs or webs *d* are disposed radially to allow cooling water to flow from the circumference to the centre, and the inner member *b* has formed integrally with it, at or near its centre, an elongated boss or tube which extends to the full depth of the outer member. The water is led to and circulated through the ducts *e* from the cylinder water jacket *f*. After issuing from the ducts *e* in streams at a high velocity, the water enters a course *h* formed in the outer member *a* and is delivered through an orifice *j*. The inner member *b* has a flange *k* on its circumference which registers with a groove in the cylinder liner *l*. (*Sealed.*)

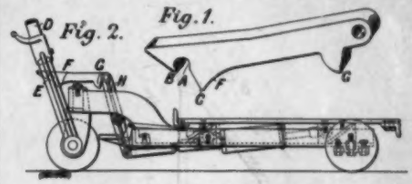
LIFTING AND HAULING APPLIANCES.

160,843. J. W. White, Widnes. Overhead Wire Ropeways. (4 *Figs.*) November 26, 1917.—In wire ropeways and tramways in which the load is carried upon a rope supported at intervals by standards and a separate haulage rope is provided adjacent to the carrying rope certain difficulties are met with when it is desired to pass the hauling rope around a corner. These difficulties are overcome by this invention which consists in providing the supporting standard with a horizontal roller 5 overlapped by a pair of vertical rollers 6, 7 at an angle to it. A cage is thus formed for the hauling rope 8 completely open at



the top, from which, however, the rope cannot escape unless it is definitely lifted out. The hauling rope 8 is gripped by a fixed jaw 9 and a movable jaw 10 pivoted thereon at 11, the first jaw 9 being connected by a bell crank lever 12 with the frame 13 of the carriage 14 running on the supporting rope 1. The jaws 9 and 10 have bevelled front and rear parts 16, 17, so that when passing a standard having a roller 5 overlapped by a pair of rollers 6, 7, at right angles to it, no side thrust is placed on the hauling rope, but the gripper passes through the standard in a straight line. (*Sealed.*)

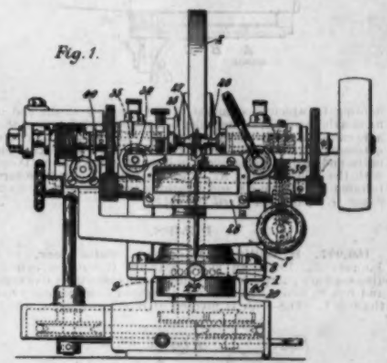
160,989. A. Collis, Maiden. Lifting Trucks or Transporters. (3 *Figs.*) January 17, 1920.—The lifting truck or transporter to which the improvements according to this invention are applicable is of the type in which the platform is raised by hydraulic means, the hydraulic pump being worked from a handle, which can be utilised for steering, through a catch pivoted to a rocking bar actuating the pump plunger and provided with a recess for engaging a pin on the handle bracket. The object of the invention is to free the catch from the handle by an operation of the handle itself. For this purpose, there is provided on the underside of the catch a pro-

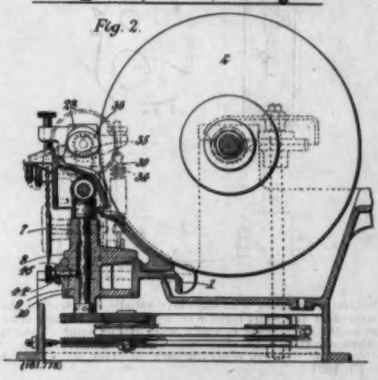


jection C, which extends from the portion A of the recess B. In pumping, the pin E on the handle D engages the recess B; when pumping is finished, the handle D is released from the catch by pushing it fully back, thereby causing the pin E to pass down this projection C to its rear side, which is also angled as at F. A sharp pull applied to the handle D causes the pin E to ride along the rear side of the projection C, and to throw up the catch, thereby allowing the handle D to be moved forward with the pin E clear of the recess B before the catch falls. (*Accepted April 13, 1921.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

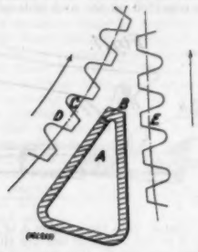
161,778. A. B. Symons, London, and C. B. Ustonson, Palmers Green. Lens Edge Grinding Machines. (3 *Figs.*) February 18, 1920.—In a lens edge grinding machine which may be used both for grinding automatically the edges of lenses used in rimless spectacles and having a square edge, and also for grinding automatically the edges of lenses mounted in rims, that is, having a V-shaped edge, the lens 38 is frictionally held between supporting discs 26, 27 in a lens-carrying frame 28 mounted so as to rock towards and away from the grinding wheel 2 under the action of a spring 39, and a template 40 carried on the frame and engaging with a finger. The lens-carrying frame 28 is pivotally mounted on and movable about an axis which permits the lens to be presented to the grinding surface of the grinding wheel with its plane at an angle thereto, and said axis is always a tangent to the periphery of the grinding wheel 2. One, 26, of the lens-supporting discs is arranged to be spring-pressed and the other, 27, to be positively adjustable in an axial direction by means of a pinion 34 engaging a rack on a sleeve 35, within





which the spindle 25 of the disc 27 rotates, for the purpose of allowing the edge of the "V" which is to be formed on the lens edge, to be brought on to the pivotal axis of the lens-carrying frame. 7 is a frame mounted on a plate 8 having a downward projection 9 of circular section, which projection is carried in a bearing 10 in the base plate 1. A "V" sighting groove on a block attached to the lens-carrying frame 28 is arranged immediately opposite the pivotal axis of the frame 7; by placing a pointed rod in the groove, the lens 38 may be correctly positioned with the point of the "V" to be formed on its edge on the pivotal axis of the lens-carrying frame, which axis is a tangent to the periphery of the grinding wheel 2. To provide means of adjustment for wear of the grinding wheel 2, the base plate 1 is movable towards and away from the grinding wheel, and is secured by bolts. A pin 44 on the base plate engages holes 45 on the projection 9 of the frame 7, so that the frame can be secured in the positions required for grinding a V-shaped or a square edge on the lens. (*Sealed.*)

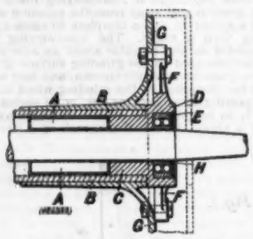
161,255. John Brown and Co., Limited, Clydebank, and W. H. Wood, Clydebank. Lubricator. (1 *Fig.*) January 2, 1920.—A sprayer for delivering lubricating oil to the working faces of gear teeth has the sprayer body A shaped to conform substantially with the bight of the gear members D, E. The sprayer body is preferably pear-shaped or triangular-



shaped, in cross-section, to permit accommodation of the narrow end in the bight of the gear members D, E and in close proximity to the region of contact. An aperture B is provided in the side of the sprayer body, in such position that the oil is delivered into the interdental spaces C of the pinion D at the nearest position to the region of contact. (*Sealed.*).

MOTOR ROAD VEHICLES.

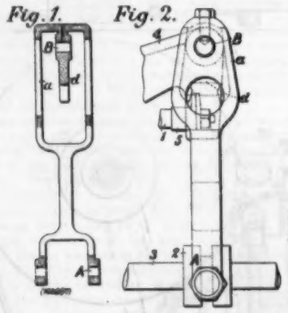
161,333. F. Bolton, Nottingham. Rear Axles. (2 *Figs.*) January 22, 1920.—In a motor car rear axle of the kind in which the axle runs directly on roller bearings disposed in the axle casing, ball bearings E, H are applied supplementary to the ordinary roller bearing A, to relieve the latter and prevent the excessive wear which is now set up. The bearings E, H are, in order that the standard type may be used, each carried in a



housing D, which is attached to the flange G at the end of the fixed axle casing B. The roller bearing A at each end of the rear axle casing B is shortened to provide room to admit a concentric extension C on the ball bearing housing D, which extension fits in the end of the axle casing B and registers the housing D co-axial with the roller bearing A. The housing D is firmly secured by forming it with arms F and attaching the ends of the arms to the flange G. (*Accepted April* 20, 1921).

PUMPS.

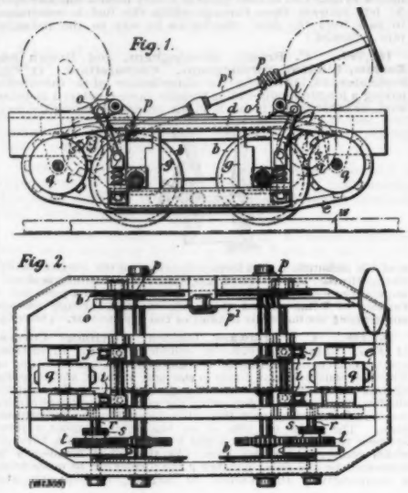
160,997. H. Williams, Barrhead. Valve Gear. (3 *Figs.*) January 22, 1920.—In valve gear for the steam cylinder of direct-acting pumps, a lever is used to operate the valve spindle 1 and has its movement from the crosshead 2 on the pump rod 3 at the end A. The lever is pivoted at B on a bracket 4, which also



carries the slide block 5 of the valve spindle, which slide block 5 is moved by the short lever *d* between the two outside arms *a* of the lever. The lever is made with double arms at the top end, thus allowing it to work clear of the bracket carrying the slide block and to work centrally with the pivot pin. (*Accepted April* 13, 1921.)

RAILWAYS AND TRAMWAYS.

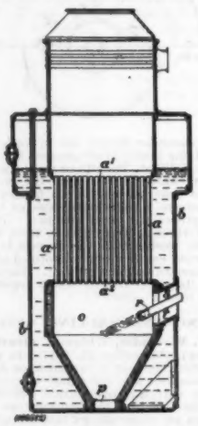
161,309. E. W. Milburn, Newbiggin-by-Sea. Locomotives. (4 *Figs.*) January 14, 1920.—In a railway locomotive used for haulage purposes on varying gradients, as in coal mines, an endless chain track *e* is provided for driving the locomotive independently of its wheels which tend to slip on the rails when climbing a gradient. The chain track *e* is brought into contact with a longitudinal strip of timber *w* attached to the sleepers. A rectangular frame is employed for the endless chain track *e*, such frame comprising two horizontal lengths of channel-iron *d*, connected together at the ends by distance pieces, the whole being designed to slide in guides *g* so that the frame can be moved vertically. At the ends of the frame there are arranged sprocket rollers *q*, *q*, designed to turn freely on cross-shafts and around which are disposed the endless chain *e* which runs in the grooves of the channel irons. The rectangular frame is raised and lowered by toggle links *i*, *j* connected to toothed quadrants *o*, which are oscillated by worms *p* on shafts *p*1. The drive from the motor is transmitted through chain or spur gearing to splined countershafts *r* fitted with gear wheels *s*, *t*, capable of sliding along the countershaft and alterna-



tively gearing with the sprocket rollers and so driving the endless chain band and with spur wheels mounted on the axles of the locomotive travelling wheels *b*. (*Accepted April* 20, 1921.)

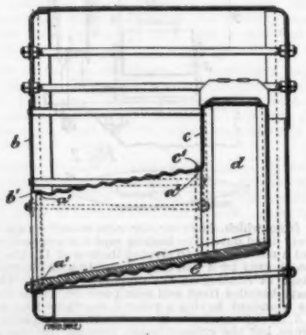
STEAM ENGINES, BOILERS, EVAPORATORS, &c.

160,912. John I. Thornycroft & Co., Limited, Westminster, and Sir J. E. Thornycroft, Westminster. Steam Generators. (4 *Figs.*) December 24, 1919.—For raising steam by the combustion of pulverised solid fuel, the steam generator comprises a nest of smoke tubes *a* arranged between a pair of tube plates *a*1, *a*2, within an outer shell *b* that encloses a combustion chamber *o* into which the pulverised solid fuel is intro-



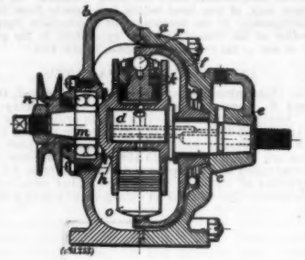
duced by a nozzle arrangement *r* adapted to direct it in a lateral or tangential direction, so that the resulting flame, due to its combustion with air in the combustion chamber, will have a circular or swirling motion imparted thereto. The combustion chamber is of hopper-like shape with a lateral air inlet *s*, *t* through which the pulverised fuel nozzle *r* extends and with a lower opening *p* through which molten slag can flow. (*Accepted April* 13, 1921.)

160,982. John I. Thornycroft & Co., Limited, Westminster, T. Donaldson, Woolston, and R. Mackie, Woolston. Steam Generators. (2 *Figs.*) January 15, 1920.—A steam



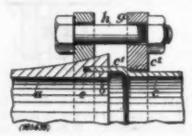
generator adapted to be fired with pulverised fuel, has a furnace shell *a*, circular in cross-section, with its ends *a*1, *a*2 oblique to its axis, so that the furnace can be arranged at an angle between the vertical walls of the generator to which its ends are secured, thus obtaining the requisite sloping floor to enable the liquid slag resulting from the burning of the pulverised fuel to be conveniently dealt with. The ends *a*1, *a*2 are housed in and secured to flanged portions *b*1, *c*1 of plates *b* and *c*, arranged at the front of the boiler and of the smoke-box *d*. The lining *e* of the furnace is of refractory bricks. (*Accepted April* 13, 1921.)

161,213. J. Maina, London. Compressors. (2 *Figs.*) November 5, 1919.—The rotary compressor, according to this invention, comprises a casing *a*, *b*, a fixed spindle *c* with an eccentric pin *d* acting as a stationary crankshaft mounted in one side *a* of the casing, and a crown *f* which rotates freely on the fixed spindle. A group of cylinders *k*, cast solid with a common base *h*, is adapted to revolve round the stationary eccentric pin *d* of the fixed spindle *c*, while a power shaft *m*, cast solid with the base *h*, is supported in the other side



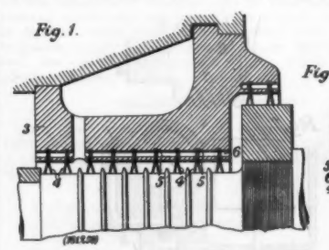
b of the casing. The bearing *n* of *m* is situated coaxially with the eccentric pin *d*. A piston *o* in each cylinder is free to obey the action of centrifugal force which keeps them constantly in contact with the internal periphery of the crown *f* and balls *r* reduce the friction between the tops of the pistons and the crown. The shaft *m*, through which the power is transmitted and the shaft on which the crown *f* is rotating, are opposed, and are mounted independently in the casing. (*Sealed.*)

161,436. The British Mannesmann Tube Company, Limited, Newport, and D. Ross, Newport. Pipe Joints. (1 *Fig.*) March 31, 1920.—In a pipe joint, one end portion of one pipe *c* is enlarged to form a plain cylindrical spigot *c*1 and the adjacent end portion of the other pipe *a* to which it is to be connected is of thickened or enlarged dimensions and formed with an annular cylindrical groove *b* co-axial with the pipe and adapted to receive the spigot *c*1 on the other pipe end, a packing ring *e* being inserted in the groove *b* and compressed therein by the spigot end of the pipe *c* when the



two pipes are drawn tightly together. This is done with the aid of two separate rings, one of which *g* bears against the annular shoulder *c*2 of the enlarged spigot end of one pipe and the other against the enlarged socket end portion of the other pipe, and both of which are connected and drawn together by bolts *h*. The arrangement is particularly applicable to Pilger tubes made by the Mannesmann process, in which one end portion of each tube is, as the result of such process, naturally formed of gradually increasing thickness towards its free end. (*Sealed.*)

161,259. A. W. Clarke, Manchester, and Metropolitan-Vickers Electrical Company, Limited, Westminster. Packing and Clearance Strips. (4 *Figs.*) January 2, 1920.—In labyrinth packings for shafts and dummy pistons of turbines having packing or clearance strips, the part 3 of the casing or fixed portion of the gland to which the strips 4 are to be attached, is provided with slots 5 adapted to receive the strips 4, the part thus slotted being pierced with a number of transverse holes 6. After the strips have been placed in position in the slots that



portion exposed by the transverse holes 6 is deformed by means of a suitable tool, so as to secure the strips in position in the slots. In this manner the strips 5 are firmly held in position without the employment of any additional screws, rivets, packing pieces or the like. To remove a strip which has become worn or damaged, the parts of the strip previously deformed are completely punched, drilled out or restored to their original form thus enabling the strip to be readily withdrawn from the slot. (*Accepted April* 20, 1921.)

FUEL IMPORTS IN ARGENTINA.—The review for the present month issued by the London and River Plate Bank states that as was to be expected, only one shipment, of 3,800 tons of bunker coal, arrived from England in the early days of May. From the United States 51,500 tons were imported, principally for account of the railways. Six cargoes of petroleum arrived from Tampico. This fuel is largely displacing the use of coal on the railways, especially in the suburban traffic.